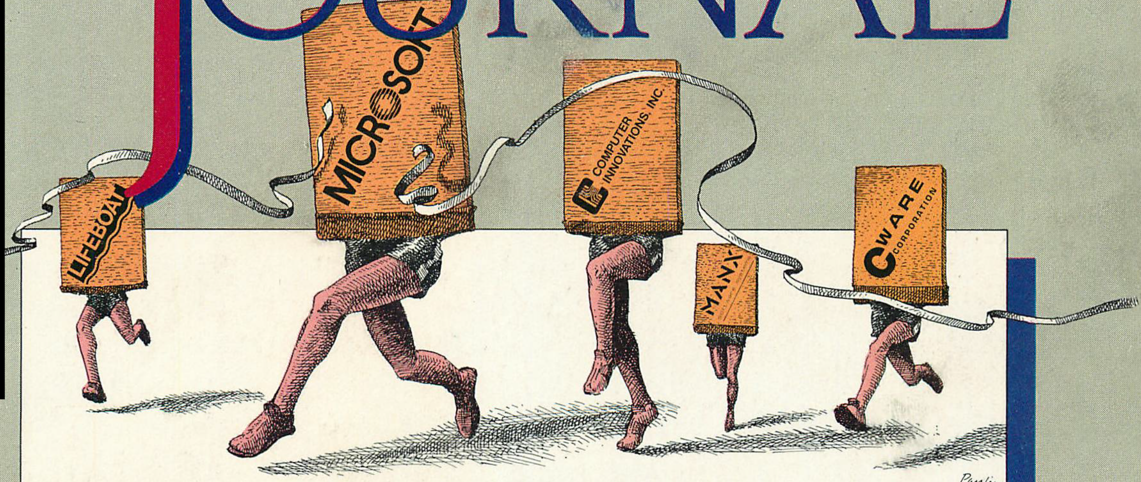
November-December 1983 Vol. 1, No. 3 $3.95

FOR IBM PERSONAL COMPUTER USERS

PC TECH JOURNAL

[redacted]



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Ten compilers reviewed: Part one

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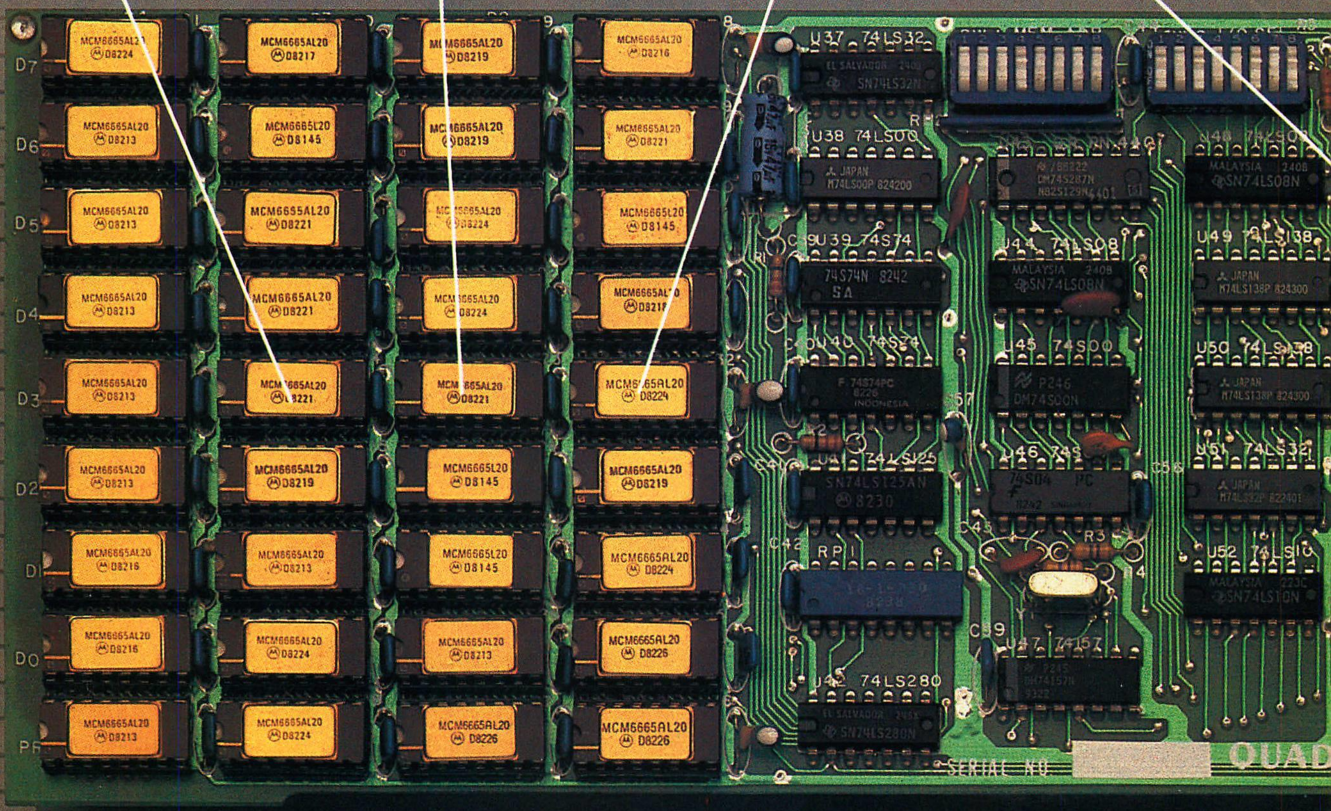

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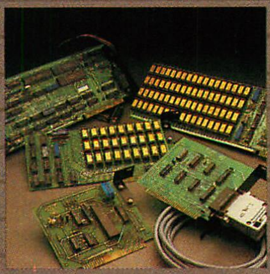

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TECH JOURNAL

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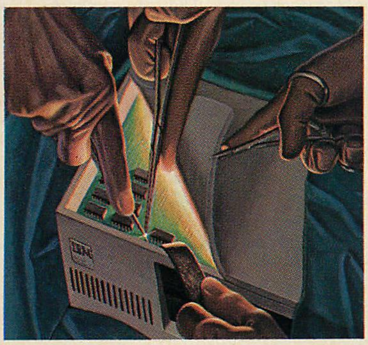

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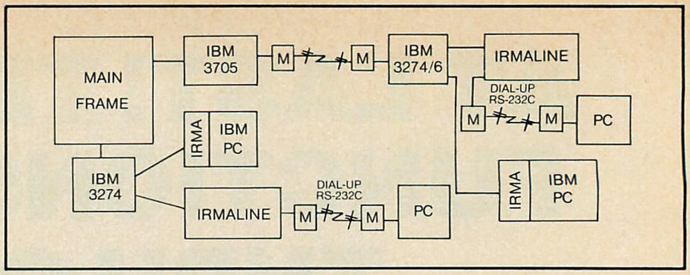

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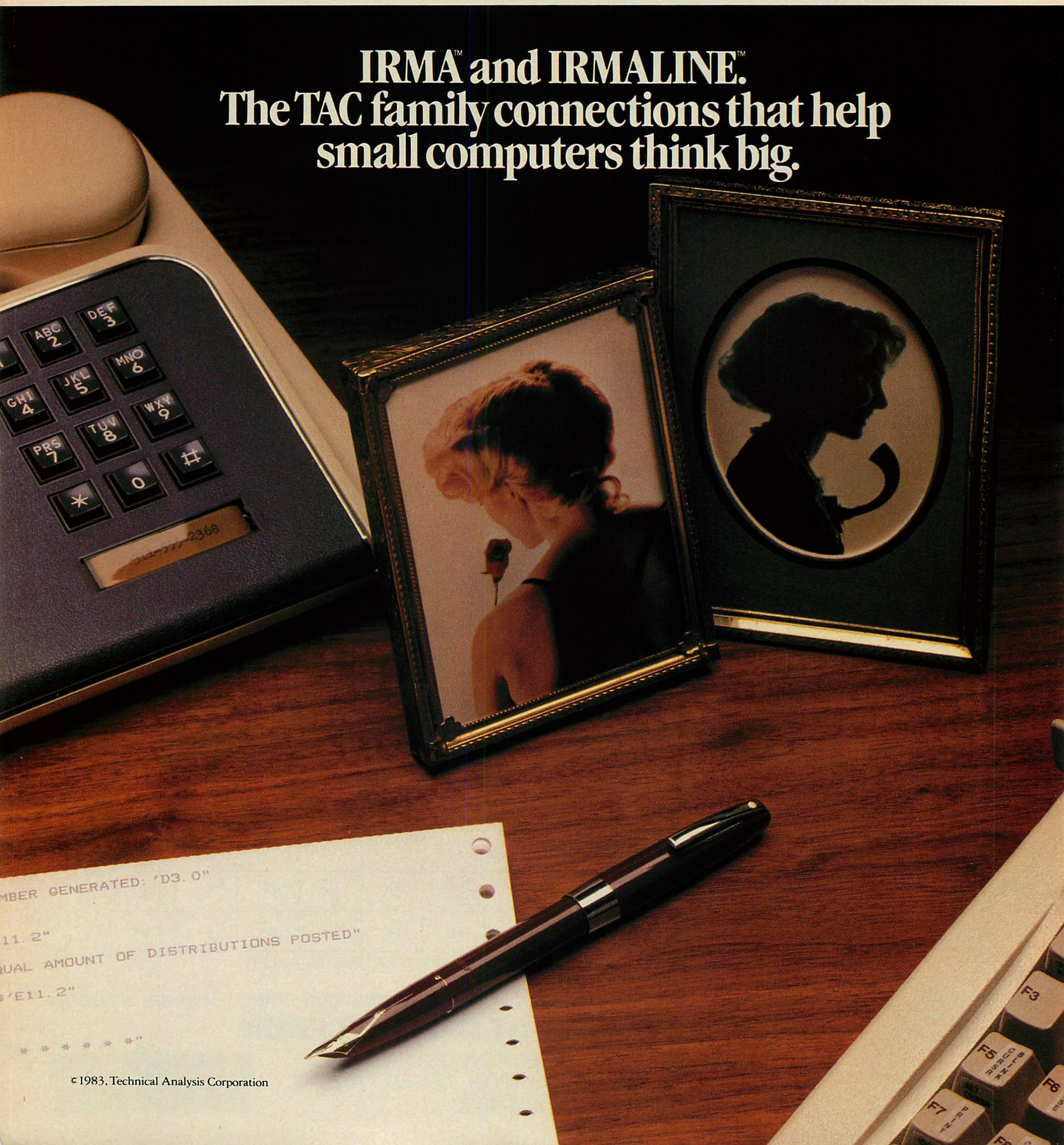


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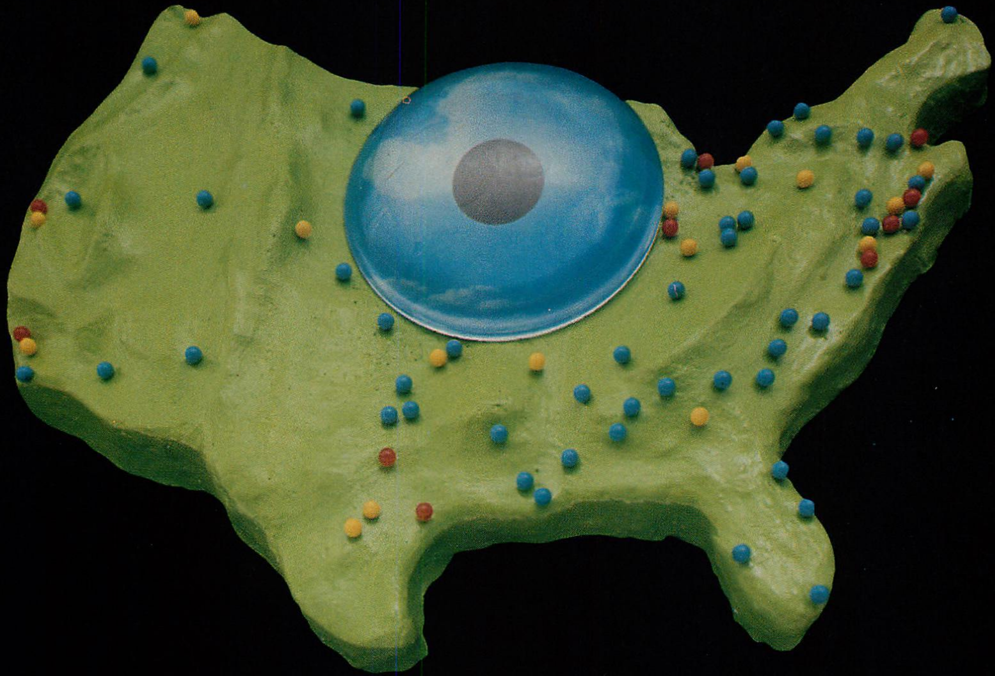

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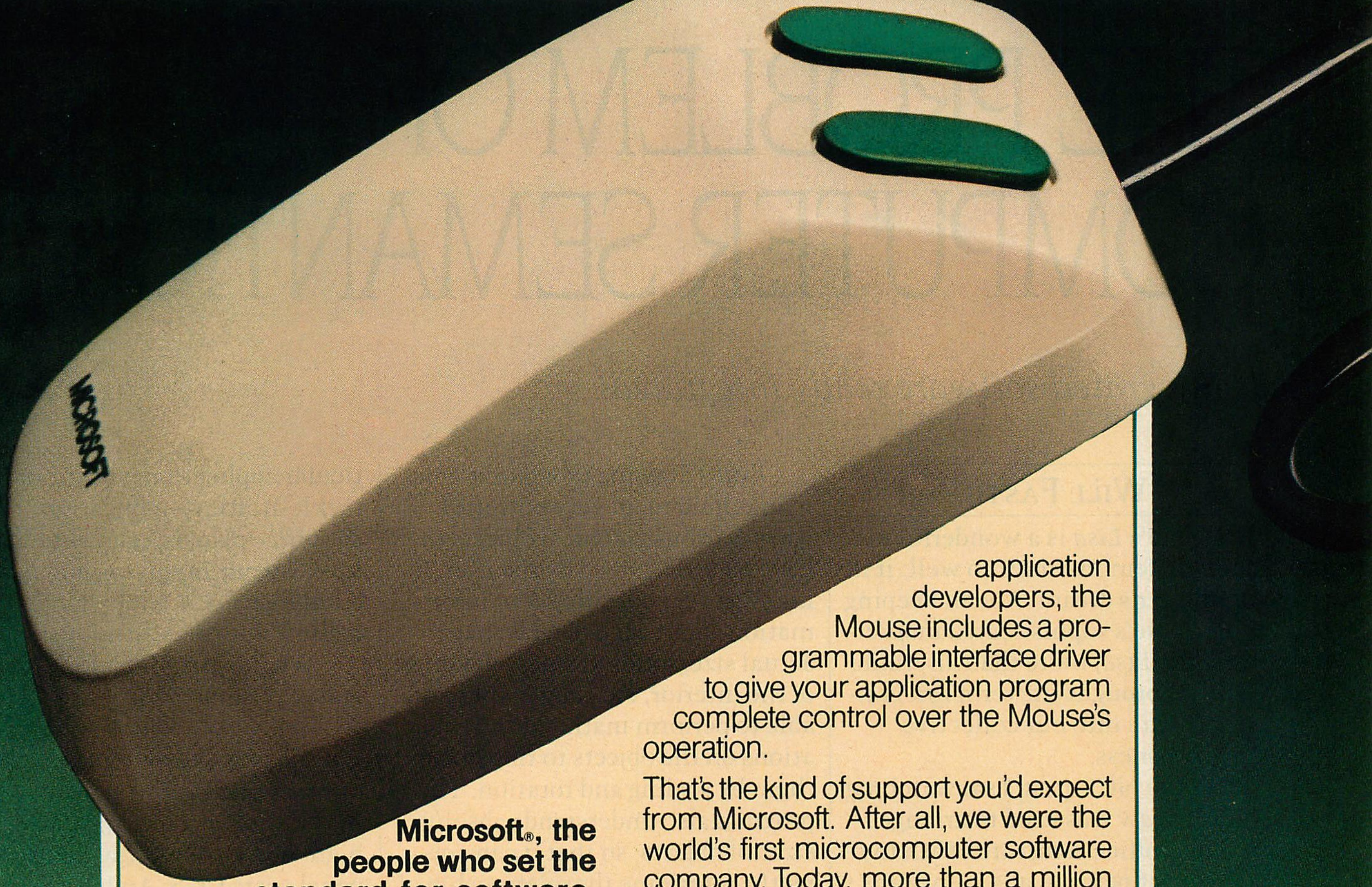

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Directions

THE PROBLEM OF COMPUTER SEMANTICS

Is integrated software really integrated?

WILL FASTIE

Apple's *Lisa* is a wonderful machine. It demonstrates so well: it is a marketer's dream. And in keeping with Apple's sophisticated marketing style, *Lisa*, more than anything else, has brought the term *integrated software* into our collective consciousness.

At the NCC past, I sat watching as *LisaDraw* was used to arrange modular office furniture. With my cynic's hat perched at a jaunty angle, I challenged the demonstrator with a series of difficult graphics tasks; only keystrokes later, I was out for the count.

Well, not quite. I did ask one more question, quietly, so as not to put the demonstrator on the spot. I asked if the information entered with *LisaDraw* could be used by the spreadsheet *LisaCalc.* The expected answer, and the one given, was no. Had it been yes, I would have sold my grandmother to buy Apple stock.

To be fair, Apple makes no claim that the drawing software is integrated with the spreadsheet. I'm not picking on *Lisa;* there is a very important issue in computer science lurking here that needs to be understood before a rational buying decision can be made regarding software that purports to be integrated.

Lisa's drawing program is able to manipulate, in very powerful ways, various graphical objects that have been described by the user. It knows a very specific set of information about each object (shape, actual size, ratios of sides, shadings of the interior, etc.) and is therefore able to perform mathematical operations on the objects to transform them by scaling and rotation. The program also understands absolute sizes of objects, so that it can correctly determine the relationship of the object to the scale of the "drawing."

Using the program, the demonstrator was able to quickly lay out a proposed open office arrangement. Changes were suggested and quickly effected. Once complete, the drawing could have been transferred to paper.

Such a design process should not stop there, however. The next phase must be a cost analysis of the layout, possibly based on competitive cost information. Ideally, the file of objects from the drawing program could be used to get all the information a spreadsheet program would need to make a parts list. For the specific application of modular office planning, such a set of programs would be relatively easy to construct. To build a set of general-purpose, cooperating programs that have no specific knowledge of a particular application, yet are able to tackle arbitrary applications like the office plan, is a gargantuan task. It is also one involving problems in computer science for which satisfactory solutions do not yet exist.

What is the problem? Simply stated, *LisaDraw* does not *know* that one of the objects with which it deals is a wall panel with fabric on both sides, electrical raceways in the bottom, standing four feet high. It does not *know* that such a panel costs $475. And worse, it cannot tell you that 13 such panels are present in the drawing.

Because it does not know these things, *LisaDraw* cannot tell a spreadsheet or any other program about the nature of its drawing. The other manipulations that a human being easily performs are a mystery to the program.

We sacrifice the ability to deal with the *semantics,* that is, the meanings and context inherent in a particular application, when we build general-purpose programs. We do so simply because we currently don't know how to do otherwise. What little we do understand today requires hardware and software resources well beyond the capability of the typical desktop computer, including IBM's Personal Computer and Apple's *Lisa.*

You might well ask why the so-called integrated packages have

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been successful so far. Why is it that Lotus' 1-2-3 is so popular? Yes, it is true that 1-2-3 can take data from the spreadsheet and graph it quickly and effectively. It is true that this feature is a valuable tool, just as *LisaDraw* is a valuable and useful tool. The right question to ask, however, is whether 1-2-3 can label each axis of a line graph from information entered in the spreadsheet. The answer, of course, is no. Although 1-2-3 is touted as an integrated spreadsheet and graphics solution, it is actually a human being who performs the integration. It is the user who labels the axes, who knows the meaning of the data.

Take this a step further. What does any spreadsheet package know about the value in a particular cell? It does understand certain relationships between that cell and others if others are referenced in the cell's formula. It categorically does *not* know that the cell contains a budgeted amount for entertainment for the month of January, 1984. *It is the human being who makes that connection;* the computer cannot.

Try this for yourself. Using the spreadsheet of your own choosing, try to reference anything in context. Oops, no fair! A reference to column G *is not* a reference to August. Oh, you chose Multiplan and named column G *August?* That's good, but it is *syntactic;* the program still does not understand that August is a month. Naming the column *Fred* works just as well. Naming the column August helps the human being perform the integration but does not take the spreadsheet program any further towards an understanding of the context.

To date, no integrated software that I know of can deal with what I like to refer to as semantic content. I do not intend this as an indictment of integrated software, but as a warning to prospective buyers that such systems deal with the mechanics of the data manipulation and rely on their human users to perform semantic integration.

I hope you noticed a new feature in our last issue: *The Tech Journal Newsline.* Containing news, views, and gossip about the IBM marketplace, the column is prepared by no less an expert than *Microsystems* editor Sol Libes. Sol previously wrote a similar column for *Byte;* it became one of its most widely-read features in that magazine.

I am absolutely delighted to announce that Sol will be sharing his insights and cranking the rumor mill on a regular basis.

Due to space considerations we were unable to give complete information about Per Brinch Hansen, who wrote "Programming in Edison" on page 84 of our September/October issue. He is Henry Salvatori Professor of Computer Science at the University of Southern California and an expert in programming language technology and concurrent systems. He developed Concurrent Pascal in 1975 and invented the monitor concept.

His most recent book is *Programming A Personal Computer* (1983, Prentice-Hall Inc., $18.95), which describes the Edison System and illustrates how the principles of programming languages, compilers, operating systems, and computer architecture are applied in the design of a complete software system.

The Edison-PC system is available for the IBM and Compaq personal computers with 64K bytes of RAM, two 320K disk drives, and parallel printer. An executable system (object code) with documentation is available for $37 and the source code for the system is available for $300 from Prof. Per Brinch Hansen, 1351 Pleasant Ridge, Altadena, California 91001.

Although our editorial policy at *PC Tech Journal* precludes the publication of articles written by authors with a vested interest in the subject matter, we invited Professor Brinch Hansen to prepare an overview of the Edison system because of its potential importance to software developers. In a future issue we plan to carry an independent review and evaluation of the Edison system.

Let Us Hear From You!

Did you know that you are part of a very special group in the computer industry? Why? Because you read *PC Tech Journal!*

This is not a magazine for everybody. We expected our readers to have a stronger technical background, to understand computer systems more clearly, and to be interested in the more complicated issues surrounding the emergence of the IBM Personal Computer. Our research indicates that we were right on the button. Our readership is a sophisticated one, and very knowledgeable in the field: 83 percent of you are college graduates, 90 percent hold professional/technical/managerial positions, and 33 percent work in M.I.S. or data processing departments. Ninety-seven percent of you use a microcomputer; 84 percent own one; you use a microcomputer an average of 25 hours a week.

To make sure we continue to serve your interests, drop us a line and let us know what's on your mind. We are interested both in your comments on what you read here and in suggestions for future topics. We are also interested in adding the names of informed and adept writers to our list of regular contributors. If you would like to contribute in that capacity, please write to us and we'll send you an author's guide. Our editorial address is as follows:

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PC NEWSLINE

Sol Libes

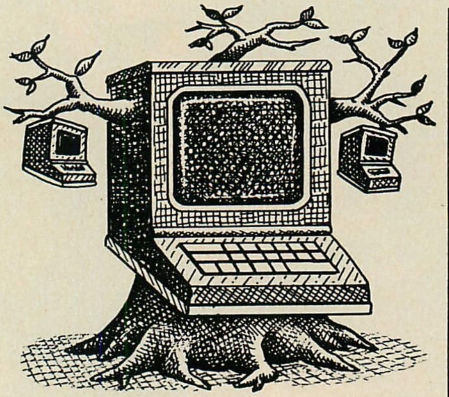
News, views, and gossip on the IBM and IBM-like marketplace

Random Rumors

This year IBM is expected to make and sell upwards of 800,000 PC/XT machines. **The rumored new IBM** home computer (see last month's column for details) is expected to hit the stores by the time this column appears (so check the accuracy of my rumor mongering). There is additional rumor that it will contain a slot for a plug-in software cartridge. Expect to see an advertising campaign for it that will be larger than the efforts of all the current home competitors combined. **Apple is also rushing** to get its system onto the market for the Christmas season. **Expect both systems** to have some upward compatibility with their standard systems, thus serving as an initial migration path up to standard systems for first–time computer users. I expect these systems to come with very good CAI (Computer Assisted Instruction) tutorials. No longer will the purchaser have to study hundreds of pages of manuals to learn how to use the machine. The machine itself will be the teacher. **Expect Lotus Development** to introduce a new version of its popular 1-2-3 integrated software package early next year (they just issued a major update). The new version is expected to include word processing and communications.

IBM Increasing Distribution

IBM has disclosed that it will beef up its retail distribution for the PC by adding another 300 dealers to its



existing 800 dealers during the next several months. With a total of 1,100 dealers, the IBM will be sold through nearly half the personal computer stores in the country.

IBM is also becoming more aggressive in the retail area. It has been establishing retail outlets (called Product Centers) across the country, opening three in 1980, 20 the following year, and 10 in the first half of this year. No doubt more Product Centers will appear at an even faster rate: there should be about 80 in operation by the middle of next year. With each store grossing about $3 million in sales, this network is becoming a big operation—one of concern to independent dealers. Although each store, staffed by five or six professionals, sells typewriters, the Datamaster, and Displaywriter systems, you can bet most of their sales are of the PC.

In another aggressive marketing move, IBM has announced that independent software and service firms that refer customers to IBM sales offices will earn referral fees ranging from 2.5 to 10 percent of resulting sales.

IBM is demonstrating to its competition how to market personal computers. It now has more retail distribution than all its competition, more salespeople selling national accounts, spends far more than any of its competition on advertising, and updates its products and offers new add-on products at a faster rate.

IBM Promoting PC to Fortune 500s

When IBM first brought out the PC in '81, it was intended mainly as a system to compete with the Apple. IBM was after the home, educational, and small business markets. Thus the original PC had a cassette interface, BASIC in ROM, and 16K of RAM. The unit was to be sold via the same dealerships that sold the Apple (most notably the Computerland chain of retail stores). But during the two years since its birth, IBM discovered that the primary market for the system was the business market, which necessitated a shift in marketing strategy.

A close look at this market disclosed that practically nobody used a cassette with the PC, virtually everyone used double-sided disk drives, and that the most frequently used software were spreadsheets, word processors, data base managers, and accounting software.

Thus, IBM introduced a new version of the PC, namely the XT, designed specifically for the business market (it is apparent that IBM intends to further enhance the machine for this market). To move the XT, IBM is turning its attention to its large national accounts. It has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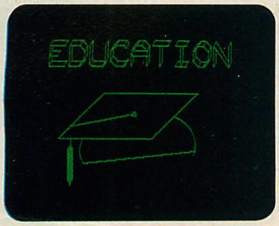

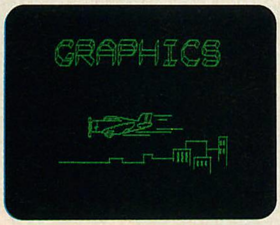

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TELEPHONE SUPPORT
available through modem board)
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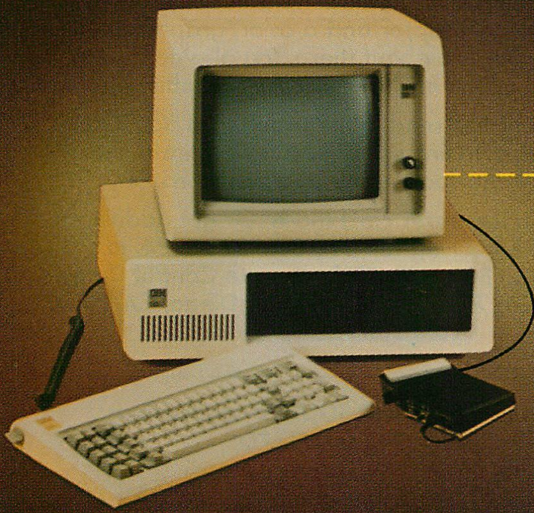
SECRETARY $1695[1]
- Ethernet Link
- Ethernet Companion
- ELAN Software



EXECUTIVE $2995[1]
- Ethernet Link
- Ethernet Companion
- Modem (300 Baud)[2]
- Voice Recognition
- Microphone
- ELAN Software

[1]With 1st MATE, 2nd MATE, or 3rd MATE in Station
[2]Option: 1200 Baud Modem
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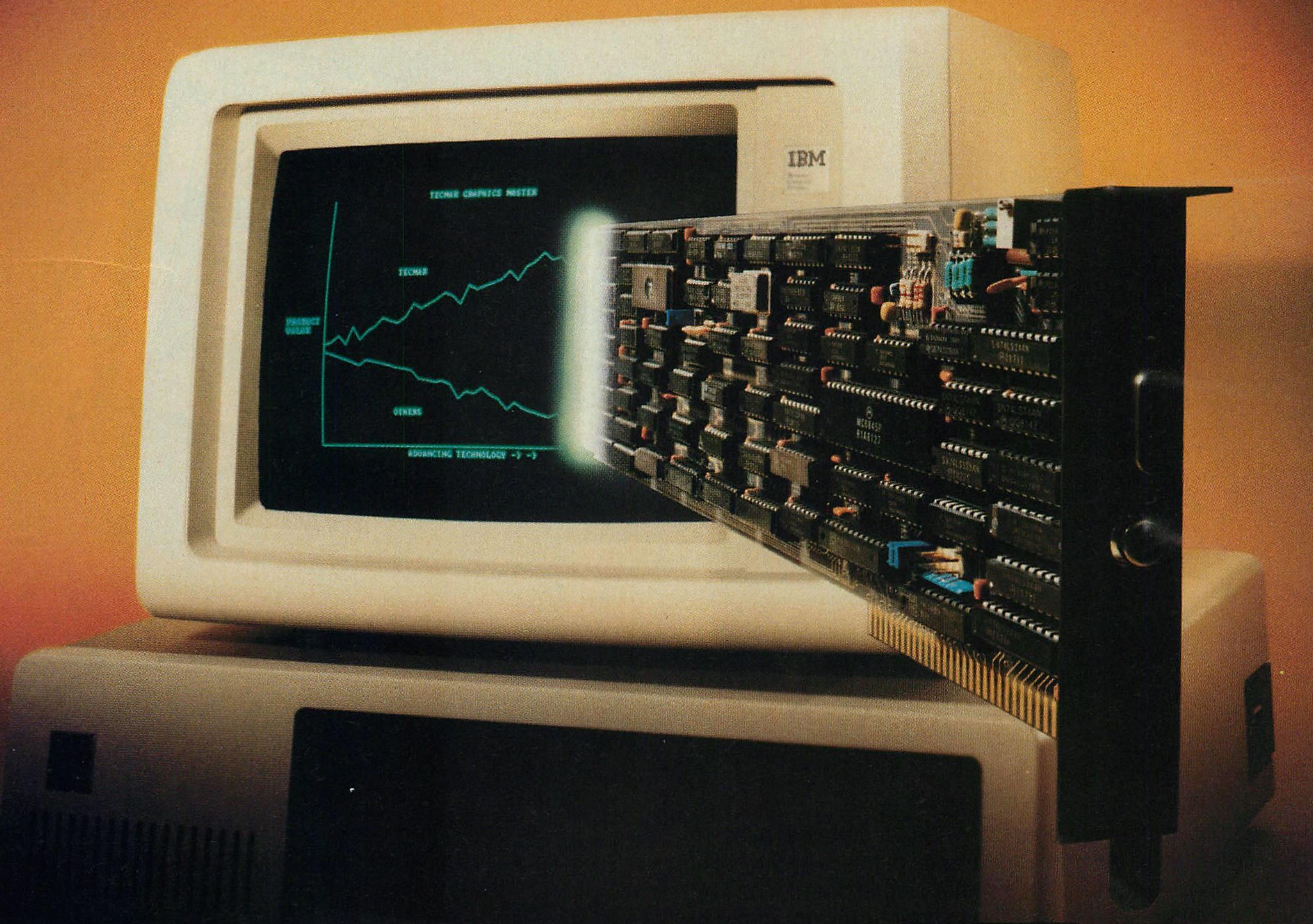
TECMAR'S GRAPHICS MASTER.™

It adds graphics to your IBM Monochrome Display, or 16 high-resolution colors to your color monitor!



Now your IBM-PC can run monochrome or color displays with remarkably enhanced graphics... and all from this one multifunction board — no other video board needed!

With your IBM Monochrome Display, the Graphics Master™ board gives you truly high resolution graphics, allowing 640 horizontal x 350 vertical pixel display.

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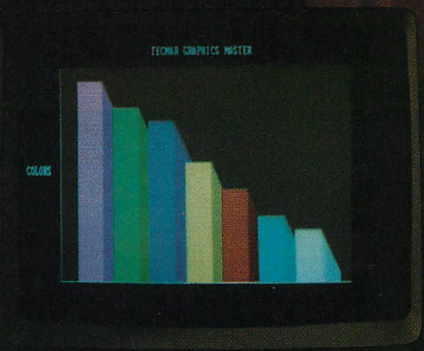
With a color monitor, it extends your color graphics to 640 horizontal x 400 vertical 16-color interlaced display.



Graphics Master™ accepts external sync, so you can add labeling to images. You can overlay characters or other computer-generated images on a video picture using the PC-Mate™ Video Cassette Recorder Controller.

This remarkable new board fully supports all IBM advanced BASIC color graphics functions.

For further information about our Graphics Master™ and the largest line of options available anywhere for the IBM Personal Computer, call or write for the latest catalog of PC-Mate™ peripherals from Tecmar.

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CIRCLE NO. 213 ON READER SERVICE CARD

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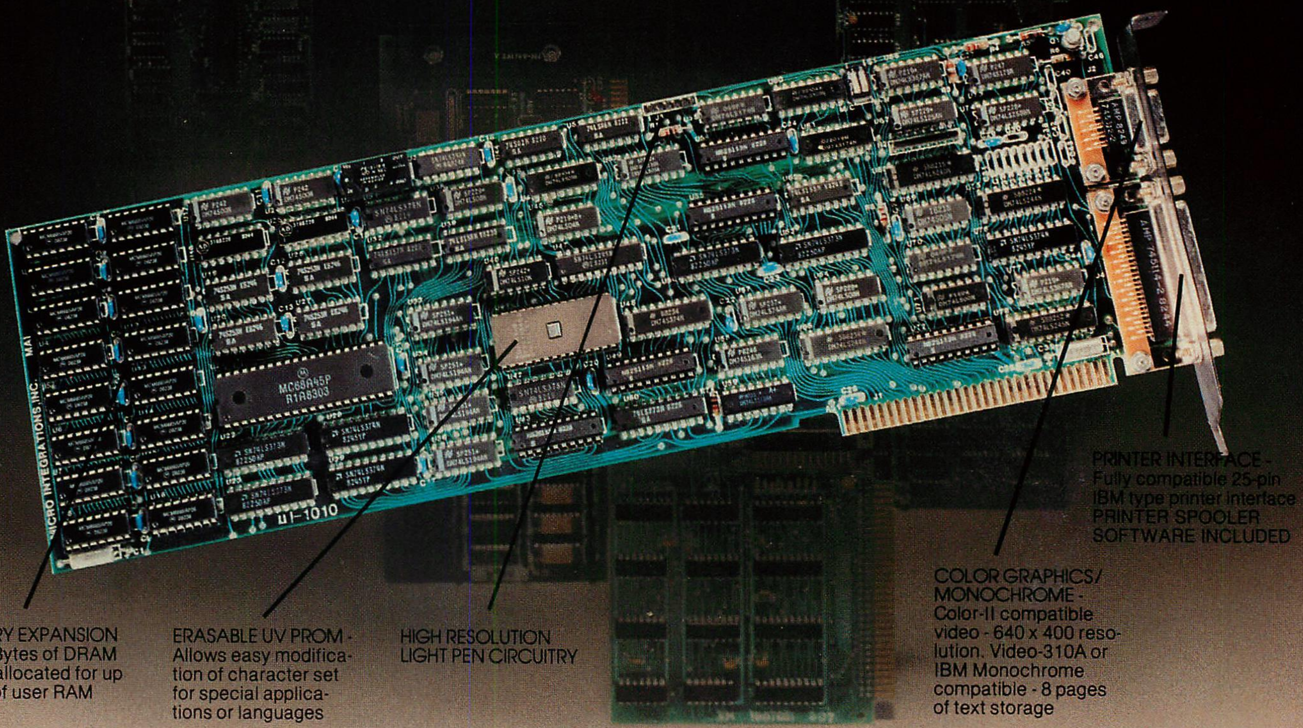
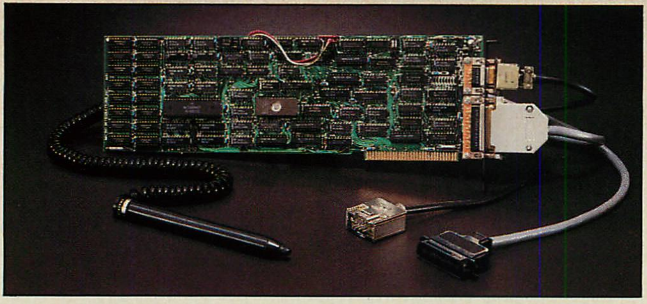


This IBM/PC compatible board provides memory expansion (128 KBytes of DRAM), monochrome or color video, light pen, and printer interface on a single plug-in board. The MAI board's high-density memory (up to 8 pictures storage) provides unexcelled color graphics enhanced up to 640(H) x 400(V) resolution in a wide variety of operating modes. Modes are selectable right on the board.



Now available with Halo* software for 320 x 200 16-color, 640 x 200 4-color, and 400 vertical line resolution modes. (*Halo is a registered trademark of Media Cybernetics, Inc.)

COMPARISON CHART

	COLOR		MONOCHROME	
	IBM	AMDEK	IBM	AMDEK
SLOT 1	Color Graphics Board	MAI Board	Black & White/ Parallel Board	MAI Board
SLOT 2	Printer Board			
SLOT 3	RAM Board 1 Slot Left*	3 Slots Left*	RAM Board 2 Slots Left*	3 Slots Left*

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put increasing emphasis on sales to major corporations via its in-house sales staff, accustomed as it is to making big dollar sales to major accounts. Until now, the attitude was that there was not sufficient dollar volume in selling PCs to justify an IBM salesperson's time and effort. That was when the PC was introduced, at a price of just over $1,000. But now, with the typical hard disk system selling for $6,000 to $7,000, and companies talking about buying hundreds of machines at a time, the IBM salespeople are getting back into the act.

Large corporations are looking at the PC and its look-alikes as both workstations for their larger systems and stand-alone systems. United Technologies Corp., in Hartford, CT, for instance, negotiated a one-shot $10 million purchase of PCs that involved 1,100 machines that will be installed around the country. General Electric Information Systems Co. in Rockville, MD, arranged a transaction whereby it resells the PC as a front end for its 750-city international timesharing network. And Travelers Insurance recently placed an order for 10,000 machines to be delivered during a two-year period, setting a record.

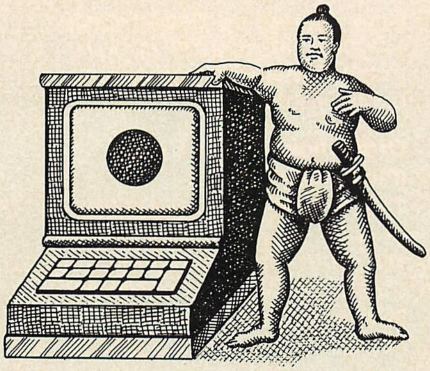
The acceptance of the PC by data-processing managers is changing the order of personal computer sales to large companies: instead of onesey-twosey surreptitious purchases by department managers, there is high-volume procurement. The soon-to-be-released local networking system and the rumored multi-user version of the PC by IBM is expected to make the PC even more attractive to large companies.

IBM Moves into Robotics

IBM currently holds less than 5 percent of the U.S. robotics market but is expected soon to make a strong bid to become the leader. It is interesting to note that IBM's Systems Product Division, located in Boca Raton, FL, is the same division that produces the PC-XT. There's a nice circularity here: The PC is being used in several of the robotic systems currently being marketed by IBM, and the Boca Raton production line that produces the PC-XT is, in turn, an in-house robotics laboratory. The plant is so highly automated, some say, that only ten minutes of human labor is invested in assembling a system.

Are the Japanese Coming?

The Japanese have been trying to penetrate the U.S. computer market now for several years. Their success record to date leaves something to be desired: an estimated less than 2 percent of the computer market, mostly in smaller minicomputers. In the personal computer marketplace its success has been relegated mostly to the components and peripherals area—printers, disk drives, etc. However, it is expected to make a strong effort in the near future in the portable and PC-compatible areas.



Dominated in the early days by American companies like Apple and Commodore, Japan now manufactures virtually all of the personal computers sold there. IBM, until 1979, was the number one computer supplier in Japan, but has been displaced by Fujitsu, which is followed closely by five other large Japanese computer companies. IBM is still fighting hard by way of cooperative ventures. To date, it has entered into agreements with Matsushita Electric to produce a personal computer specifically for the Japanese market.

While Apple has seen its foreign business falter, IBM today does 45 percent of its total business outside the U.S., accounting for 37 percent of its profits. And IBM now has 150,000 employees abroad, compared to 215,000 in the U.S. However, it should be pointed out that IBM has not met with the same success marketing the PC in Europe and Great Britain as it has here in the U.S. It was late introducing the product so that some IBM look-alikes became available before the IBM-PC. Also, a number of dealer distribution problems developed, which necessitated IBM's changing its dealer organization.

The Clash of the Titans

IBM's next big market push appears to be in the area of communications. This is actually part of its overarching scheme for the office-of-the-future, which will be totally paperless, with computerized record keeping and networks carrying messages from one desktop workstation (a PC, naturally) to another. IBM is also moving into competition with AT&T because these systems in many instances will be using telephone lines to communicate. Thus IBM recently acquired a 15 percent interest in Rolm, a manufacturer of advanced PBX systems using computerized switchboards capable of handling both voice and data traffic. Also, last year IBM won an $18 million contract to upgrade the British telephone system. It's currently performing a similar task for West Germany.

AT&T, on the other hand, has been successful in freeing itself of the heavy hand of government regulation and is moving aggressively into the computer business. Its ini-

tial thrusts have been in the area of licensing its multi-user, multi-tasking UNIX operating system and computers for use by telephone companies. However, AT&T, via its American Bell subsidiary, is expected shortly to introduce microcomputers that will compete directly with the PC and IBM minicomputer systems. There is no doubt that AT&T has resources—human, technological, and financial—comparable to those of IBM. The question is whether it can develop an equally comparable sales and service organization. The coming battle between these two colossi will take the next few years to develop; I hope to keep you posted on the fight, round by round.

IBM Moves to Dominate the Market

IBM, which entered the computer market in 1952 about six years after the business was born, rose, in 1956 to have 85 percent of the U.S. computer business. The U.S. government felt that this constituted a virtual monopoly, and in early 1969 filed a massive antitrust suit charging monopolistic and anticompetitive practices. The suit dragged on in the courts (costing both IBM and the government several hundred million dollars) while IBM held back its marketing efforts. By January, 1982, when the government decided that the case no longer had any merit, the IBM share of the computer market had dwindled to 40 percent.

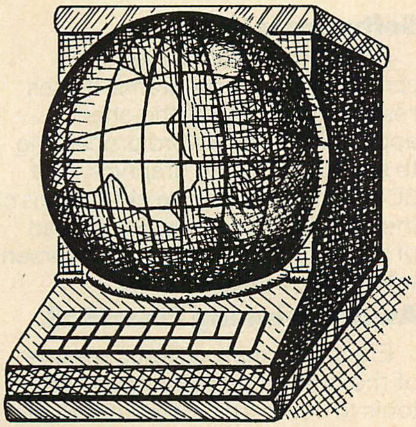
With this load off its back, IBM has become much more aggressive: Introducing new products and lowering prices, the company has become a very tough competitor. No sooner has a competitor brought out an improved IBM plug-compatible product at a lower price, than IBM has upgraded its product and/or lowered its prices. These tactics have already forced one plug-compatible manufacturer into bank-

ruptcy and several others onto the ropes. The IBM plug-compatible market, which not too long ago was considered a terrific business to get into, is now shunned by startups. IBM appears to be following a similar approach in the personal computer business.

How Big Is IBM?

Last year was IBM's best year ever with sales of $34.4 billion and profits of $4.4 billion—the most profitable U.S. industrial company. It already has an estimated 21 percent of the $7.5 billion U.S. personal computer market, in other words an estimated $1.6 billion in PC business. This year's sales of personal computers by IBM are expected to far exceed those of Apple, making IBM the unquestioned dollar volume leader in the personal computer business. All this in a little more than two years. IBM's business growth rate is typically 13%.

IBM today does 40 percent of the world's computer business (in large mainframes it is some two-thirds). Number two in the field, Digital Equipment Corp. does only 20 percent of IBM's volume. IBM has 465,000 employees (215,000 in the U.S.).



Although IBM's products are generally considered to be a step behind its competitors in technology, and IBM enters a field only after competitors have proven that there is a significant market, IBM invariably achieves success via its marketing muscle and ability to provide support. In the U.S. alone IBM has 8,500 salespeople.

Last year IBM spent $3 billion on research and currently boasts 11,000 patents. It spends $500 million on in-house employee training. In the last six years it has spent about $10 billion upgrading its manufacturing facilities. IBM is now the largest manufacturer in the world of IC logic and 64K memory chips (all used in its own machines) and is expected to be the first company in volume production of the new 256K RAM chips.

Unix for the PC

UNIX, the multi-tasking, multi-user operating system developed by Bell Labs is already being made available by five companies for the IBM-PC! Mark Williams of Chicago, Whitesmiths Ltd. of Concord, MA, Sritek Inc. of Cleveland, Quantum Software Systems of San Jose, and Lantech Systems of Dallas. Not only that, there are rumors that VenturCom of Cambridge, MA, and Microsoft are both porting their versions of UNIX to the PC. And to add more grist to the rumor mill, there are rumors that IBM itself will release a version in the not too distant future.

IBM Offers LAN License

At the most recent meeting of the Institute of Electrical and Electronic Engineers (IEEE) Local Area Network committee meeting (IEEE project 802 committee), IBM formally made public an offer to license its token-ring LAN technology, for a one-time charge of $2,000. The general reaction of committee members was lukewarm.

Network your PCs now, and we'll give you a first class send off.

Networking your IBM PCs with 3Com EtherSeries is one of the smartest business moves you'll ever make. It's an investment in the future that will bring your business communications into the electronics age, now. Cut your operating costs, now. For a price that makes sense, now.

EtherSeries.
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Lots of smart business people have chosen EtherSeries as their network. For good reason. Ethernet is the industry's high-performance networking standard. And EtherSeries is the most advanced, most practical Ethernet-based networking system available. Our founder, Bob Metcalfe, invented Ethernet. 3Com knows Ethernet like no other company, because 3Com *is* Ethernet.

Sharing means Savings.

Most people talk about what networking costs. EtherSeries users know what it saves. Time. And money. Here's why: add an IBM XT server or our more powerful server, and you're ready to use 3Com's EtherShare. With it, everyone on your net has access to the same disk files, while password security and locking features protect confidential company information. PC users can also share the same letter-quality printer—without ever leaving their station.

Software is the key.

EtherSeries doesn't require special software programs. It uses readily available, off-the-shelf applications, from word processing to spreadsheet and graphics. And 3Com now offers network versions of the popular VisiSeries. So instead of buying a package for each person who'll use it, you buy *one*.

Award-winning EtherMail.

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Free Electronic Mail.

any time, day or night. A special message editor helps you compose your message quickly using sophisticated word-processing features. Then, just push a button and our award-winning EtherMail option transmits your letter or memo from PC to PC electronically. You save postage, phone charges, time and the aggravation of playing "telephone tag."

Growth Without Grief.

When you're ready to expand your network, EtherSeries won't give you any growing pains. You can link up to 1024 PCs—at any time—for $950 each. So you never pay for more capability than is needed. And it's so easy to do, you can install it yourself with just a screwdriver.

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Your PC investment pays huge dividends when you link it with an EtherSeries Network. And for the next 90 days, we'll make a smart decision even smarter. Purchase a basic EtherSeries with links to three PCs and we'll give you our award-winning EtherMail software at no additional cost.

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Letters to the Editor

Color Graphics

I noticed in your article by Thomas V. Hoffmann (*PC Tech Journal*, July/August, 1983) that you are highly critical of the IBM manuals. However, I feel your article does little to clear the air. It's true that it did successfully break down the board into its basic components, but your language was so technical that your detailed explanations might have well been Chinese. I cite the frequent appearance of sets of letters like "&H3D4." I realize that such sets may be easily understood by those with Ph.D.s in computer science, but to those of us who aren't as educated but are still interested in the workings of the computer, the article is far from understandable. I suggest that you continue your excellent in-depth evaluations but use simpler terms.

Amr Razzak
Timonium, MD

We agree completely that cryptic notations sometimes obscure the point. We're stuck, though, because there are no standards for the notations we need to use. The set of letters you mention is BASIC's notation for a hexadecimal value of 3D4; BASIC was chosen for the Hoffmann article because his program examples were given in BASIC. For an article about an assembly language program the value would have been written 3D4H, for C, 0X3D4, and for IBM Pascal, 16#3D4.—WF

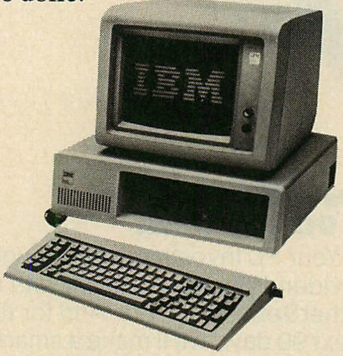
Choosing a C Compiler

The article by Bill Hunt, "How to Choose a C Compiler" (*PC Tech Journal*, July/August, 1983), indirectly brings up an important programming consideration. With the recent proliferation of C Compilers (and UNIX-like systems for that matter), there is a critical need for an official C language standard. Although the Kernighan and Ritchie book is quite extensive in its description of the C language, it still contains many ambiguities. Furthermore, a number of semi-official extensions have been added to C since the Kernighan and Ritchie book was first printed (1978). A standard set of system functions is also critical to program portability. Such standards are in the works. I hope they will be ready and widely accepted before C meets the same fate as BASIC and Pascal.

Marc MacLennan
Santa Barbara, CA

PC Keyboard

In the first issue of *PC Tech Journal*, Editor Will Fastie complains about the PC keyboard for, among other things, the placement of the function keys. Why, he wonders, did IBM put the function keys on the left instead of across the top of the keyboard as everybody else has always done.



Mr. Fastie claims that the function keys are in an "awkward position," stating that "the Control and Alt combinations (with function keys) usually require the right hand for the Alt key while the left strikes the desired function key, thus removing the hands quite far from the normal typing position.

Now really! The farthest function key from Alt is F1, only four inches away. The distance between Alt and F10 is a single inch. Mr. Fastie's hand can't reach that? What tiny hands he must have! If the function keys were across the top of the keyboard, it would be 4 inches between Alt and the closest function key, F1, and a full 12 inches to F10. Both hands WOULD be required to reach the combinations. Mr. Fastie has distorted the truth to support a prejudice. For generations, IBM has been world-renown (sic) for the brilliance of its industrial design. I find the ability to use fingers of the left hand on Alt, Cntrl, and all function keys to be a vast improvement over the across-the-top design, which is pointless unless the keyboard is integral with the display. My hand is always close to normal typing position.

If function keys can be exactly below the display of their function on the monitor, then there is a reason for the across-the-top design. IBM has followed federal guidelines for computer design, based on studies that demonstrate that detached keyboards create less user fatigue. This detachment eliminates the need for top keys and frees the designer to place the function keys where they can be operated with one hand with Control and Alt.

PC Tech Journal is a much needed publication, if it is accurate, but Mr. Fastie's curious reasoning certainly raises some doubts.

Owen Findsen
Cincinnati, OH

Errata

We received several letters regarding the programs that accompanied the article "A Diversionary Benchmark," in Vol. 1 No. 1 of the TECH JOURNAL. We provided both BASIC and a Pascal versions of the program (page 194), but the Pascal versions contained a typographical error. The correct version follows.

COHERENT™ IS SUPERIOR TO UNIX* AND IT'S AVAILABLE TODAY ON THE IBM PC.

Mark Williams Company hasn't just taken a mini-computer operating system, like UNIX, and ported it to the PC. We wrote COHERENT ourselves. We were able to bring UNIX capability to the PC with the PC in mind, making it the most efficient personal computer work station available at an unbelievable price.

For the first time you get a multi-user, multitasking operating system on your IBM PC. Because COHERENT is UNIX-compatible, UNIX software will run on the PC under COHERENT.

The software system includes a C-compiler and over 100 utilities, all for $500. Similar environments cost thousands more.

COHERENT on the IBM PC requires a hard disk and 256K memory. It's available on the IBM XT, and Tecmar, Davong and Corvus hard disks.

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CIRCLE NO. 164 ON READER SERVICE CARD

Mark
Williams
Company

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*UNIX is as trademark of Bell Laboratories.

```
PROGRAM HAT;

($N+)(TURN ON NATIVE CODE GENERATION)
(R-)(TURN OFF RANGE CHECKING)
USES TURTLEGRAPHICS;

CONST
  P=160;
  Q=100;
  XP=144;
  YP=56;
  ZP=64;

VAR
  XI, YI, ZF, XF, ZT, XT, XR, YY, XPZP : REAL;
  XP2, ZI, XL, XI : INTEGER;
  FOREVER : BOOLEAN;
  A : INTEGER;

  BEGIN (** MAIN PROGRAM **)
    XR := 1.5*3.1415927;
    XF := XR/XP;
    XPZP := XP/ZP;
    XP2 := XP*XP;

    ZF := XR/ZP;
    FOREVER := FALSE;

    FOR ZI := -Q TO Q+1 DO
      BEGIN
        IF (ZI > -ZP) AND (ZI < ZP) THEN
          BEGIN
            ZT := ZI * XPZP;
            XL := TRUNC (0.5 + SQRT (XP2 - ZT*ZT));
            FOR XI := -XL TO XL DO
              BEGIN
                XT := SQRT (XI*XI + ZT*ZT) * XF;
                YY := (SIN (XT) + 0.4 * SIN (3 * XT)) * YP;
                XI := XI + ZI + P;
                YI := YY - ZI + Q;
                SETPIXEL (0, XI, YI, 2);
              END;
          END; (IF)
      END; (NEXT ZI)

      REPEAT
        A := A+1
      UNTIL FOREVER;

  END. (** MAIN PROGRAM **)
```

NEC 765 Controller

You mentioned that the NEC 765 controller can support both the 5¼-inch and 8-inch drives. How can one go about using this capability? Does this involve rewiring or changing a ROM on the disk controller board? Can this be done entirely by software as you stated using a utility package such as Henderson's JFORMAT as advertised in your journal?

Francil S. Nakayama
Phoenix, AZ 85040

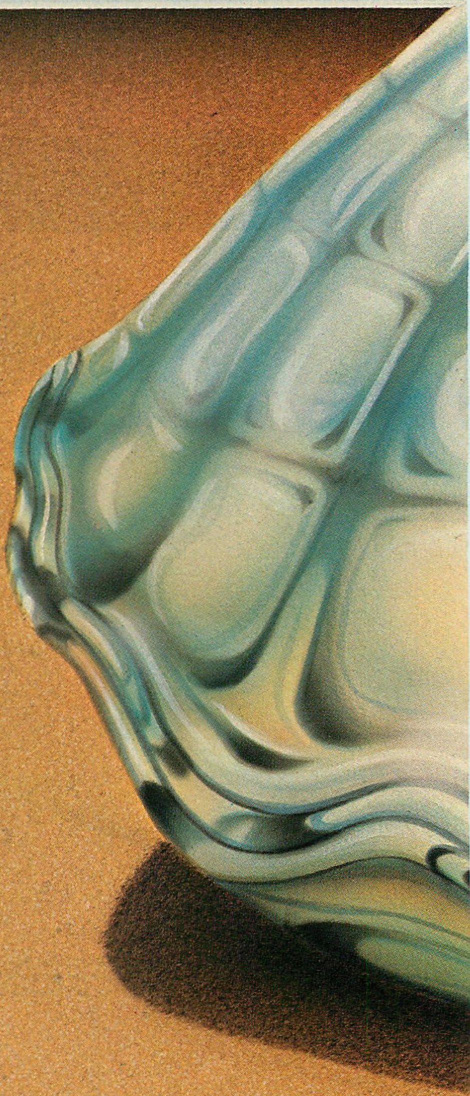
The floppy controller is under the complete control of software and can be reprogrammed to deal with 8-inch drives. A number of companies offer such upgrades for the PC; no ROM change is required. We will deal with the 765 in a future issue.—WF

SOFTWARE REVIEW

THE SHE

Three cover-ups for MS DOS: What the well-dressed operating system could sometimes use.

SUSAN GLINERT–COLE

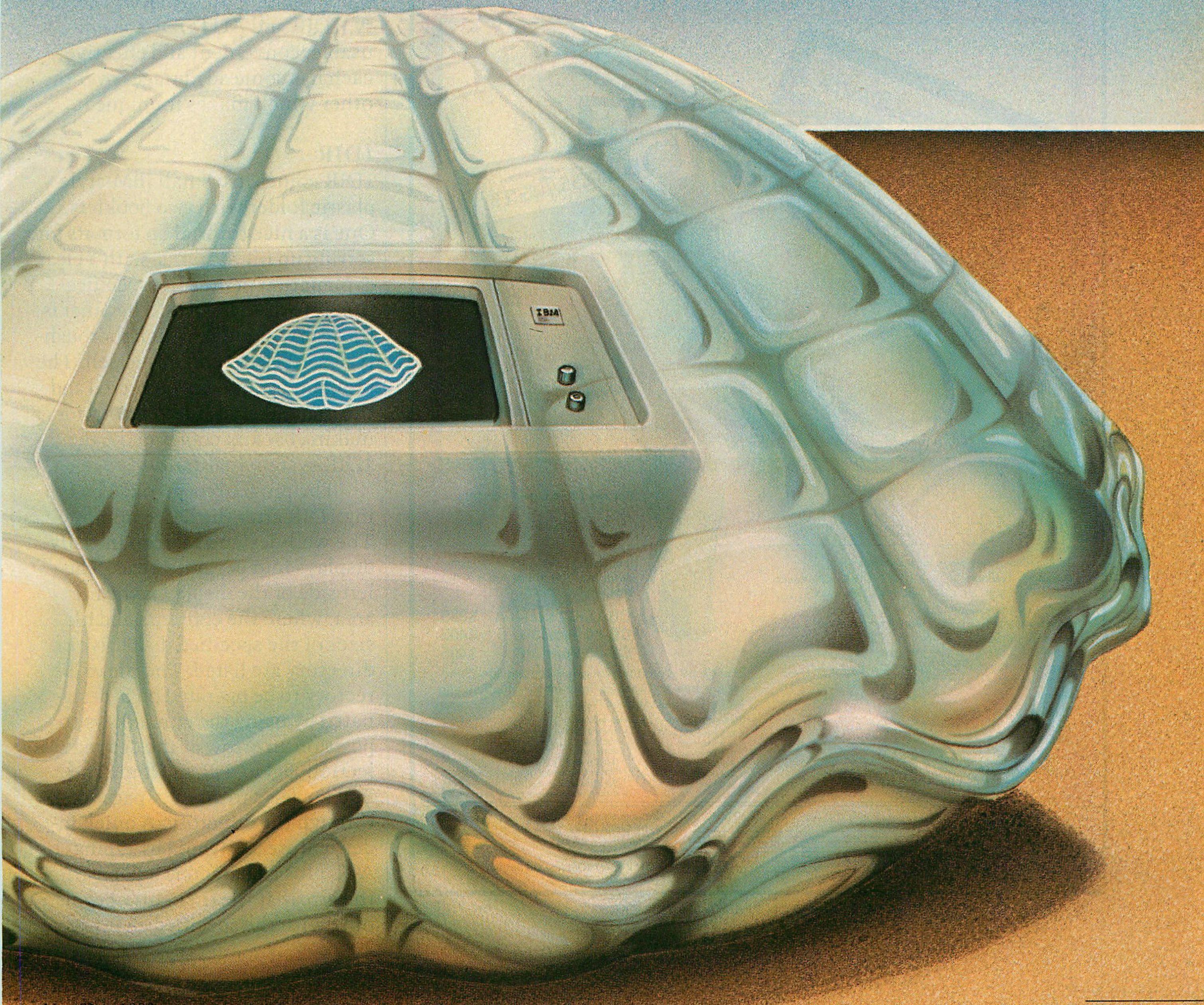


INTRODUCTION

It is a fact of life that effective use of an operating system requires a thorough study of the documentation and good memorization skills if the command syntax is to become second nature. Microsoft DOS certainly doesn't lend itself to casual users, lacking, as it does, coherent menu prompts and a well-organized manual. MS-DOS is becoming a force to be reckoned with, particularly for people who are trying to use it. Software is now beginning to appear that removes the user from direct contact with the operating system by building an interactive "shell" around it.

These products are not aimed at system developers or programmers

LL GAME



with extensive experience. Rather, they are meant to appeal to the businessman or home user who is occasionally required to interact with the operating system (to format a diskette for example). This is not to say that an expert could not benefit from the convenience provided by a shell. A programmer who is intent upon the latest piece of software will appreciate the ease with which directories may be searched and errant files located.

Typically, shells present a menu display with the various options available, such as ERASE, COPY and so on. The user merely has to position the cursor at the desired option, and press one key to execute the command. If well implemented, the shell makes it very easy to carry out commands which, if attempted directly in MS-DOS, might require a few retypings to get the syntax correct. Error recovery should be impeccable. Shells that are poorly designed present the user with a more complicated set of commands to memorize than is available with the basic operating system itself and respond to an incorrect command by tossing the user back to DOS.

Of the three shells reviewed in this article, one of them belongs, unfortunately, to the latter category. 1DIR and AUTODEX are quite usable, convenient and effective; each has some advantages over the other which makes it unique.

1DIR

1DIR comes in a small IBM-style plastic folder with two booklets. One is a nice tutorial on formats for setting up file systems, with a clear explanation of how file specifications are used in DOS. The other is the user's manual, which thoroughly describes the software itself. The program is not copy protected and the manual gives instructions for making backup copies using the 1DIR system (naturally).

The program is invoked by typing 1DIR after the DOS prompt. The well-designed screen initially displays four separate areas. The left side of the display is the file area, where the contents and file sizes of the specified disk drive or directory are listed. The file or directory to be operated on is designated by using the cursor keys to position an arrow at the desired selection. PgUp, PgDn, Home and End are used to quickly page through the directory. A quick index feature, activated by typing ALT plus a character, will position the arrow at the first entry beginning with the specified character.

The center of the screen is used for system statistics. Listed here are diskette usage in hidden and user files, space used and available on both the disk and in memory, the date and time.

There are two ways to enter a command: by moving the cursor to a command listed on the screen and pressing the enter key, or by selecting the COMPOSE mode and then typing the desired command.

The left side contains an area that displays the current state of the toggle keys (Num Lock, Caps Lock, and PrtSc) and set-up menu. This menu is used for changing the default drive, the displayed drive, initiating sorts by file name or extension and a PAUSE command toggle. After 1DIR has completed an operation, it normally requires an extra keypress to return to the 1DIR menu. This design prevents any program output on the display from being instantly replaced by the menu. A 'pause' option will toggle this feature off, if the extra keypress is not desirable.

Along the bottom of the screen is a menu displaying DOS's internal commands. These commands are invoked by positioning the cursor on the desired command and pressing the return key. Erasure requests are always followed by a warning and require a reply before they are executed.

The cursor keys are used to move around the display. An arrow is always positioned in the file area, and the command selected in the command area is displayed inside the arrow, so you are always aware of what you asked for and where you have been.

There are two ways to enter a command: by moving the cursor to a command listed on the screen and pressing the enter key, or by selecting the COMPOSE mode and then typing the desired command. The ability to enter commands not available on the menu is an excellent feature which neither AUTODEX and FileCommand have.

When 1DIR is initialized, it automatically comes up in the COMPOSE mode, with the cursor ready to accept a command. COMPOSE is always used in conjunction with another menu command: EXECUTE. In the COMPOSE mode, a DOS command may be typed out, or the many shortcuts provided by 1DIR may be used to create the command without the hazard of

typing it out by hand. For example, positioning the pointer to a file and then pressing the plus key will copy the file name on the composing line. When the command has been assembled, the command cursor is moved to EXECUTE and the return key is pressed. Commands can only be constructed in this manner from file names in the currently displayed directory. This is too bad; 1DIR would be much more powerful if provision were made to allow command composition from different directories. This option is useful nevertheless for entering more complicated commands than 1DIR can handle with its cursor keys and menu choices.

An executable file can be run simply by positioning the file pointer to the program name and moving the command cursor to RUN. This alleviates the necessity of remembering all the executable file names on a fixed disk.

If the file pointer is positioned at a directory, or subdirectory, RUN will list the contents contained therein. It is very easy to page through a complex file hierarchy with 1DIR. The only complaint about this implementation is that the name of the directory is not displayed when the contents are listed in the file area. This is a curious omission because it becomes necessary to go one level up to see what subdirectory is being shown on the screen. Even worse, 1DIR's relative position in the subdirectory hierarchy is unknown and can only be found by performing upward directory scan.

Each disk can be given an identifying name of up to six letters and each file can have a file description of up to 42 characters.

1DIR is impervious to user error; I was unable to make it crash or produce inexplicable results. An error is signaled by a single low-pitched beep. It is also perfectly logical in its operation. It doesn't get flustered when asked to display the files in drive Z; it shows you exactly what's there . . . nothing.

Autodex

The only documentation supplied with the review copy was the quick reference card. The information it contained might be adequate for an instant refresher, but did not explain many of the advanced features mentioned on the card. While AUTODEX will run in DOS 2.0, the version reviewed does not give the user access to subdirectories. This makes AUTODEX effectively useless for hard disks, although the company indicated that an updated version should be available by the time this article appears.

The display is divided between the file area and the disk area. The former contains all the file information such as disk space available, file size, date of last update, and current default and backup drives. Each disk can be given an identifying name of up to six letters and each file can have a file description of up to 42 characters. This is a good feature, but it does take a 3K bite out of the available disk space.

As in 1DIR, the current file had an arrow pointing to it that can be moved around with the cursor keys. While the pointer is positioned at a file name, various commands can be executed by typing one letter. Thus, L will list the file to the printer, R will rename the file, X will execute the program, V will view the file in Hex and ASCII and so on. The erase, backup or list commands can all be used in conjunction with the multiple (M) command, so all files can be erased at once. Erasures are prompted by a warning message, and an extra keypress insures that accidental file loss is kept at a minimum. Most of the commands have some message attendant on them, so that you are always reminded of what you intended to do or what you just did.

If an executable command requires parameters (FORMAT, for example, needs a drive specifier), the user may enter them at the prompt which follows the X command. This is a much easier way to enter information than that provided by 1DIR, where the entire command, including the file name, must be composed and then executed.

The B, or backup command, is a very useful feature that will back up the current diskette to a specified drive, and identify it with the same name.

The B, or backup command, is a very useful feature that will back up the current diskette to a specified drive, and identify it with the same name. This is less tedious than the format required for DOS of COPY X:*.* Y: and more comprehensible to infrequent users of this command.

The multiple command, M, allows users to mark files for use with backup, list and erase commands. This function is akin to the wildcard specifications of DOS, but may be used more selectively. Erasing many files on one diskette can be a chore however; it is easier to perform this function with the DOS wild card feature.

The view command is one of AUTODEX'S most convenient features. In addition to displaying text files, the program neatly outputs executable files in hexadecimal and ASCII, with the offsets displayed in the left hand column. Non-printing ASCII characters are represented as periods, and the display contents can be sent to the printer via CTRL + PrtSc.

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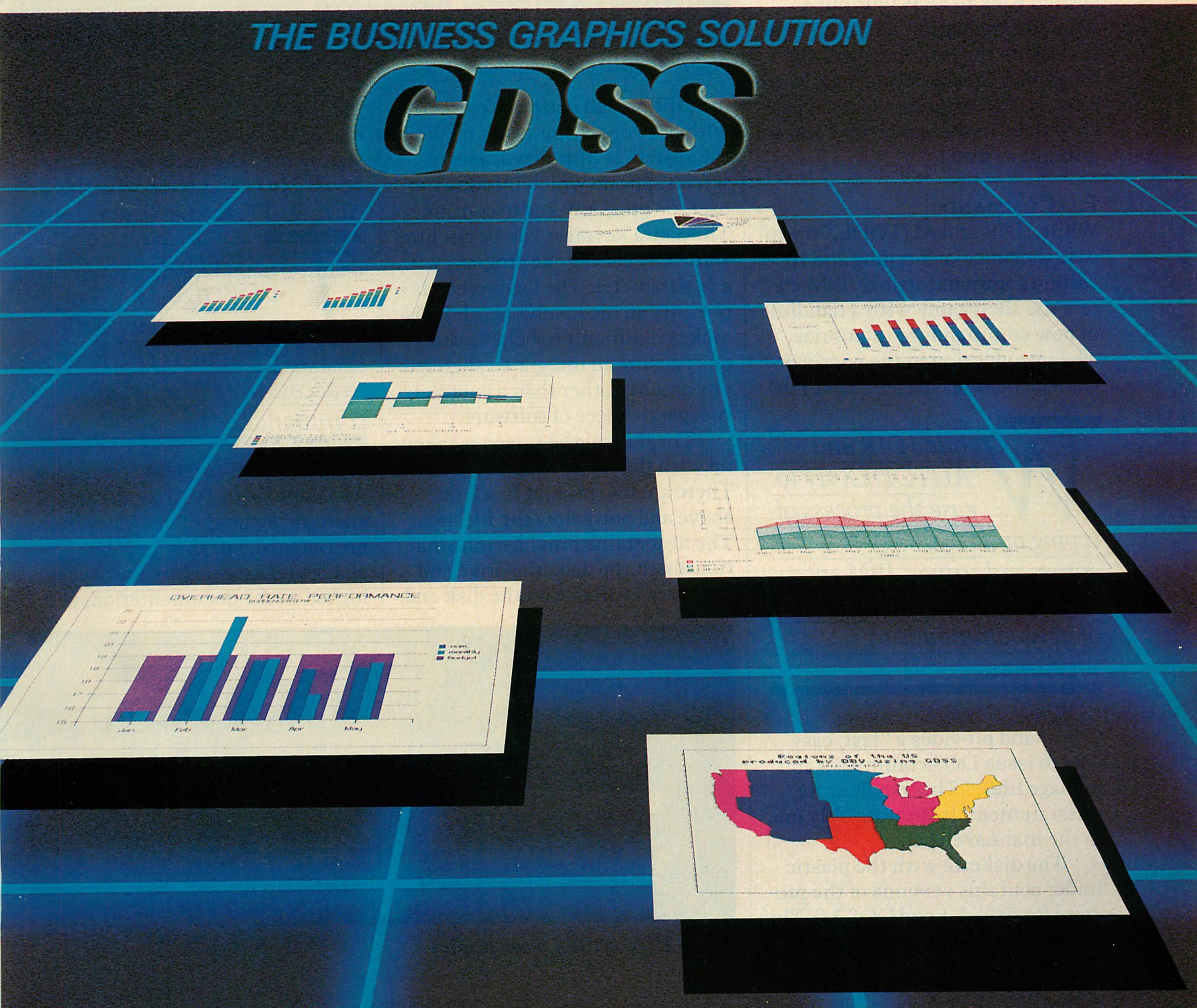


CIRCLE NO. 251 ON READER SERVICE CARD

The disk area has five functions which can be executed by positioning the cursor to the desired command and pressing RETURN. One keystroke enables you to sort by name, type, size or date, gives a printout of all the files on the default disk with related information, obtains date and time and exits to DOS.

AUTODEX exits to DOS whenever it perceives something unusual. There is no recovery from disk errors, and the program is relatively easy to crash. Specifying a nonexistent drive confuses it, and some honest errors on my part threw the system back to DOS without a word of explanation. Listing a non-text file to the printer causes the program to freeze, requiring a warm reboot. Disk error messages appear embedded in the screen text and are difficult to read.

FileCommand

While 1DIR and AUTODEX try to ease the process of typing and recalling command strings, IBM enters the shell game with a handful of new commands to memorize. The introduction to the poorly organized manual suggests that File-

While 1DIR and AUTODEX try to ease the process of typing and recalling command strings, IBM enters the shell game with a handful of new commands to memorize.

Command provides a "fast, easy way to issue DOS commands and manage files." This is a definite misstatement. It isn't the only one in the manual either.

The diskette with the plastic folder contains versions of the program for DOS 1.1 and DOS 2.0. This arrangement is not as convenient as

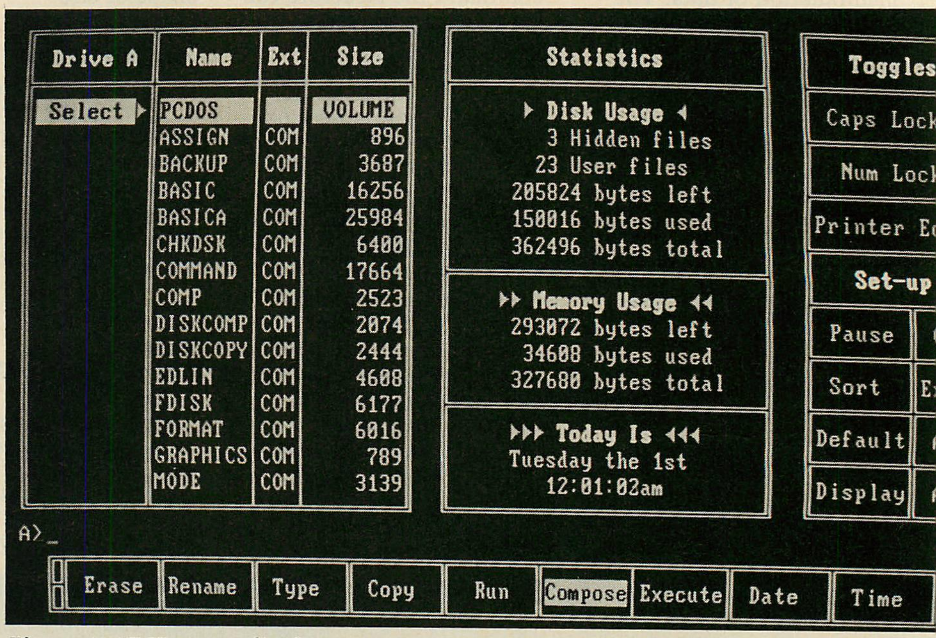


Figure 1: 1DIR menu display

in 1DIR, which performs perfectly with both operating systems. When the system is initialized, a logo screen appears which informs the user to "press any key to continue." This extra keypress can be circumvented by calling the program with a /q parameter. The logo screen is not only an inconvenience, but also makes it difficult to believe that one is using an integrated shell environment, rather than a completely separate piece of software.

The bulk of the screen is taken up with the file description area. There are two prompt lines: one above and one below the file area. The header line provides information about the disk, the drive and the space available on the disk and in memory. The bottom prompt displays the main function key assignments. The function keys may be used in conjunction with the ALT, SHIFT, and CTRL keys to

The function keys may be used in conjunction with the ALT, SHIFT and CTRL keys to access over 40 different commands.

access over 40 different commands. ALT-alphabet keys may also be customized by the user. They come preassigned, but they may be changed. Assignments are not catalogued in the documentation; you

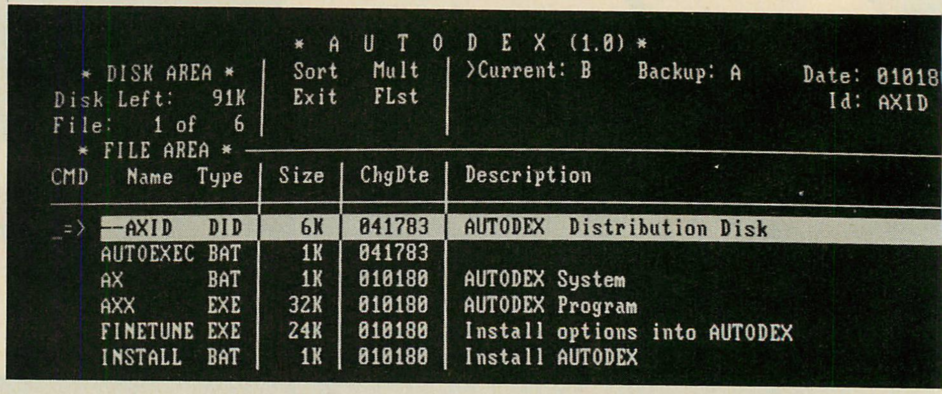
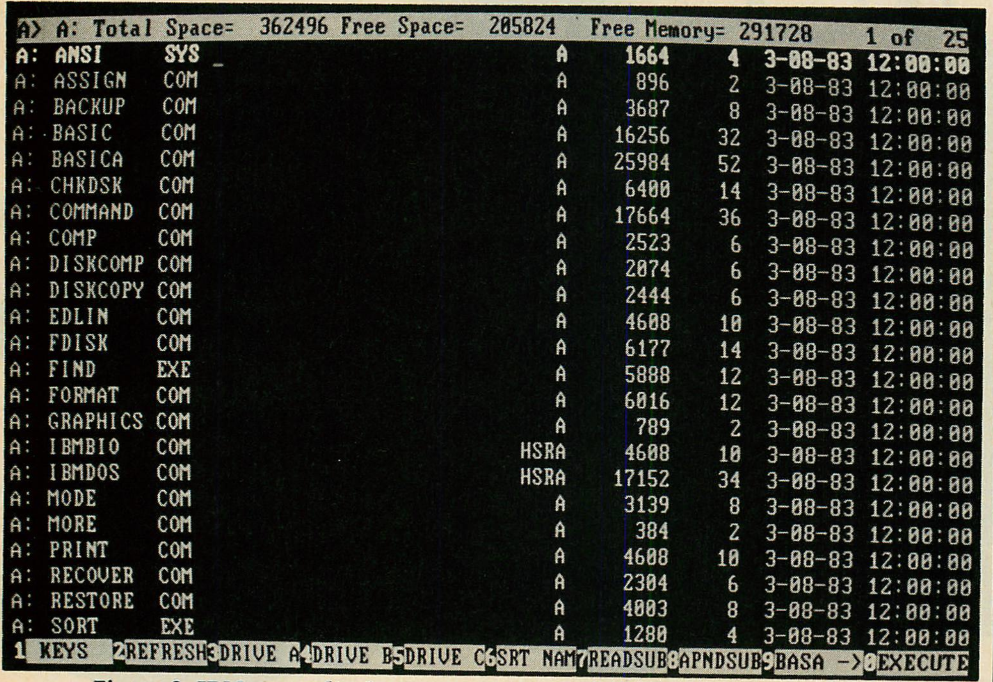


Figure 2: AUTODEX menu display

view key assignments by hitting function key #1.

The file description area lists the files on the diskette, along with their various attributes, such as file size, hidden or system, number of sectors the file occupies, and the date and time the file was last updated. The DOS 2.0 version also indicates whether the file has been updated since the fixed disk was last backed up. There are no column headers on the screen to remind you of what all this information is. If you have been away from the program for a while, it is necessary to reread the manual to recall which column is which.

The command structure itself is knotty.


A> A: Total Space= 362496 Free Space= 205824 Free Memory= 291728 1 of 25

A:	ANSI	SYS	A	1664	4	3-08-83	12:00:00
A:	ASSIGN	COM	A	896	2	3-08-83	12:00:00
A:	BACKUP	COM	A	3687	8	3-08-83	12:00:00
A:	BASIC	COM	A	16256	32	3-08-83	12:00:00
A:	BASICA	COM	A	25984	52	3-08-83	12:00:00
A:	CHKDSK	COM	A	6400	14	3-08-83	12:00:00
A:	COMMAND	COM	A	17664	36	3-08-83	12:00:00
A:	COMP	COM	A	2523	6	3-08-83	12:00:00
A:	DISKCOMP	COM	A	2074	6	3-08-83	12:00:00
A:	DISKCOPY	COM	A	2444	6	3-08-83	12:00:00
A:	EDLIN	COM	A	4608	10	3-08-83	12:00:00
A:	FDISK	COM	A	6177	14	3-08-83	12:00:00
A:	FIND	EXE	A	5888	12	3-08-83	12:00:00
A:	FORMAT	COM	A	6016	12	3-08-83	12:00:00
A:	GRAPHICS	COM	A	789	2	3-08-83	12:00:00
A:	IBMBIO	COM	HSRA	4608	10	3-08-83	12:00:00
A:	IBMDOS	COM	HSRA	17152	34	3-08-83	12:00:00
A:	MODE	COM	A	3139	8	3-08-83	12:00:00
A:	MORE	COM	A	384	2	3-08-83	12:00:00
A:	PRINT	COM	A	4608	10	3-08-83	12:00:00
A:	RECOVER	COM	A	2304	6	3-08-83	12:00:00
A:	RESTORE	COM	A	4003	8	3-08-83	12:00:00
A:	SORT	EXE	A	1280	4	3-08-83	12:00:00

1 KEYS 2REFRESH 3DRIVE A 4DRIVE B 5DRIVE C 6SRT NAM 7READSUB 8APNDSUB 9BASA -> 0EXECUTE

Figure 3: IBM menu display

The cursor keys are used to run a highlighted line up and down the list of files. A prompt on the top line tells the user what line the cursor is on; this information is of dubious worth and the space on the prompt line could have been used to better effect.

The general idea behind FileCommand is to position the cursor in the command area, which is the free space between the file name and the remaining file data, and then type the command. This must be followed by a CTRL + RETURN. Alternatively, the plus key on the numeric keypad may be used to enter the command. If either combination is held down too long, the program retreats transiently to DOS. Control can be passed back to the program by hitting the RETURN key.

The command structure itself is knotty. All commands are prefaced by a (/), and then executed with the additional keystrokes mentioned above. Unlike 1DIR and AUTODEX, commands are not executable through a menu. The commands themselves are confusing and do not always work as expected. The r command is variously referred to as a Replace, Refresh, Return and Remove command. In addition, syntax rules must always be kept in mind as well; /r/ is not the same as /r, which in turn differs from /r filespec.

The /p command is supposed to display information on paths; this did not work in the version reviewed here. Path information is obtained by typing the same syntax as found in DOS—e.g., level1/level2/level3. The same information is displayed too, making one wonder what advantages FileCommand has over the bare operating system.

It is possible to append directory listings to each other on the display (there is no alteration on the disk) with the /a command. The number of directories which can be so appended must be specified with the /fn parameter if more than the default number is desired. The default is 8, which means, curiously, that 7 files may be appended to the current directory, for a total of 8.

The biggest drawback of FileCommand is that programs may not be directly executed from the display if they are not in the default directory. This is a problem found in DOS 2.0 which 1DIR handles automatically by changing the directory before executing the requested program. FileCommand claims that any file with a .COM or .EXE extension may be executed from the display, but this feature didn't work in the review copy without a manual change to the default directory.

The biggest drawback of FileCommand is that programs may not be directly executed from the display if they are not in the default directory.

Final Considerations

AUTODEX and 1DIR provide considerable conveniences and enhancements not offered by MS DOS, but both exact a price for these available features. AUTODEX is very fast and allows the user to stroll through a file with a few keystrokes. It substitutes in a small

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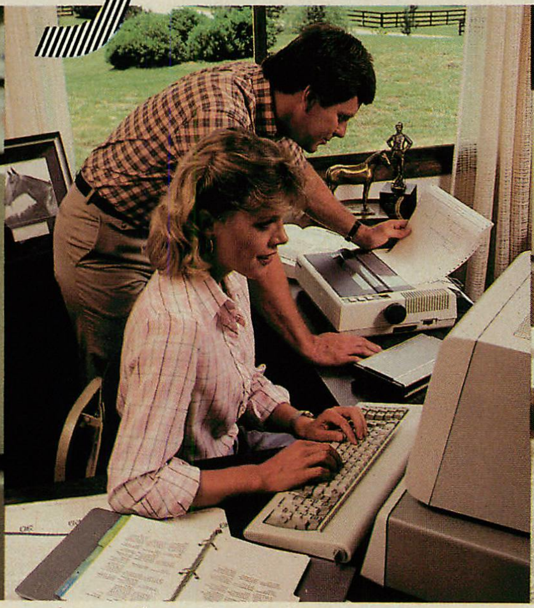
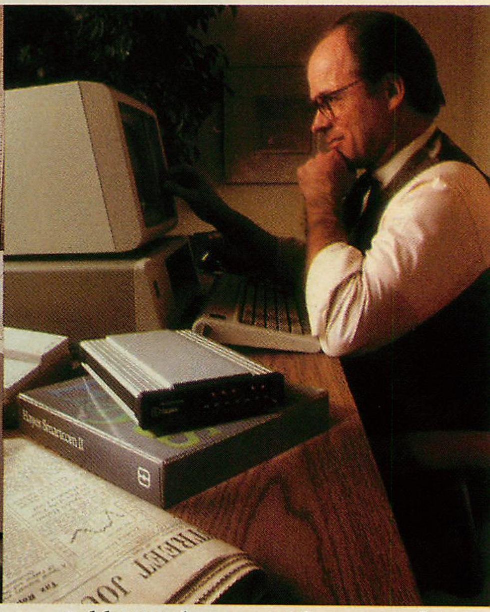


Gary: The pedigrees for next week's auction are as follows...



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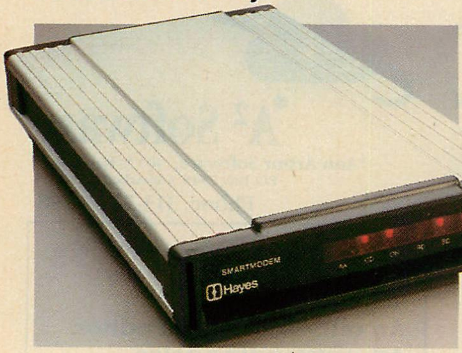

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way for a file management program by providing disk labels and file descriptions, and easing the chore of making backup disks. On the other hand, error recovery is not very good, although familiarity with AUTODEX's foibles would minimize the frequency of fatal blunders. The program is also bulky, occupying about 53,000 bytes of disk space plus an extra 3K for the header file. This almost requires it to be placed on a separate diskette and takes away from its use as a resident utility. Finally, AUTODEX is very expensive at $150. If the error trapping were improved and the tree-structured directories of DOS 2.0 supported, this product would be worth the price.

AUTODEX and 1DIR provide considerable conveniences and enhancements not offered by MS DOS, but both exact a price for these features.

1DIR performs flawlessly and provides a simple way to traverse subdirectories. Files can be executed from any level. It is not necessary to change the default directory as in FileCommand and AUTODEX did not support hierarchical directory structures. It is also small enough, at 9700 bytes, to be resident on most diskettes. This feature makes it function more as a real shell around the operating system, rather than as an auxiliary program. 1DIR appears slower than both AUTODEX and FileCommand as the screen is redrawn each time the menu is reentered (after a program has been executed, for example). As long as the user remains within the menu area, 1DIR executes the commands as rapidly as the other two shells.

At $96, 1DIR is not inexpensive, but the price may be worth any number of retypings, bad command errors and misplaced files.

FileCommand has neither the pleasant ability to view a file that AUTODEX does, nor does it allow execution from any subdirectory, as 1DIR will.

FileCommand does have some features not available in 1DIR and AUTODEX such as directory append and the ability to exclude certain files from the displayed listing. The cost exacted for these functions is the time required to learn and then type the complicated commands. FileCommand has neither the pleasant ability to view a file that AUTODEX does, nor does it allow execution from any subdirectory, as 1DIR will. While FileCommand is priced competitively at $35 and has a reasonable file size of 15,000 bytes, it does not perform as described in the manual and certainly does not alleviate the problem of complicated command entry.

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AutoDex
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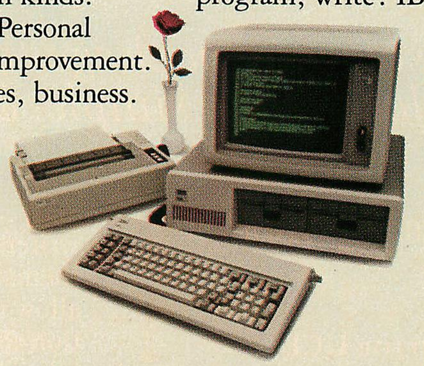

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UCL
A USER COMMAND LANGUAGE

Amid a blitz of software packages claiming to be "integrated," our author pleads for a simple, consistent user interface.

Eliezer Naddor

The Need for UCL

The time has come for the computing community to agree on a generally accepted User Command Language—a minimal set of commands and command formats easily grasped by programmers, manual writers and, foremost, by users themselves. Such a language should allow the user to obtain information about the commands themselves, about the data used by the program, and about other sources of

Eliezer Naddor is a professor of mathematical sciences at The Johns Hopkins University.

data and their formats. The commands should allow the user control over the amount and format of the information supplied. And there should also also be commands providing examples of the precise format of designated commands.

I realize that for certain applications and for novice users, the use of menus, pointers, and special keys may be suitable as command languages. However, this article will not concern itself with such languages.

An Existing UCL

I have been designing, coding, and implementing computer programs since 1955 for a very wide range of applications. During the last few years I have found it necessary to develop a UCL for most of my larger programs, which have been used by many students and also in industrial applications. I will first present several illustrations of my UCL and then discuss its general structure. Each command illustrated is given in the precise format expected by the program. It is then followed by a description of the action expected by the program.

HELP - Provide brief helpful information

EXA,HELP - Provide examples of the precise format for the command HELP.

HELP,COMMANDS - List all the available command roots.

SYS,FRENCH.DAT - Read the system data in file FRENCH.DAT.

FIND/FRE/FIL,RX:1930, VEND:2001 = 2999 - Find the frequency of occurrence of vendors 2001 to 2999 for patients who were prescribed the drug 1930. Display the results on the terminal and also print them in the next file in the series FIN.01, FIN.02, etc.

SIMULATE/6,SZ,-1-2,4,100.2,1-10,96-100 - Simulate an inventory system with an SZ policy using reorder points from -1 to 2 and an order level of 4. The simulation should cover 100 periods and the outputs should use printing option 2. The pertinent information should be printed for periods 1 to 10 and for periods 96 to 100. Six sets of simulations should be run.

The applications covered by these commands include a multiple choice quiz, a database manager, an inventory simulation, a game, an editor, and a mathematical programming program.

DIS/10,ROW,2,4,COL,5,10 - Display the values in rows 2 to 4 and in columns 5 to 10. Print the first 10 characters of the title of each row.

PLAY*,3,2,1.5,4 - Play a chinese checkers game with four players using a teleray as a terminal. The time limits for the players are respectively 3, 2, 1.5, and 4 seconds.

RENUMBER LIS 3000-3199/200 STEP 5 - Renumber program lines 3000 to 3199. The new line numbers should start at 200 and increment in steps of 5. List the new program lines as they are renumbered.

MAX/DUAL,TAB,FULL - Find the maximum of the current linear programming problem and display details of the simplex tables arising during the solution process. Also give the solution of the dual problem.

The applications covered by these commands include a multiple choice quiz (SYS,FRENCH.DAT), a database manager (FIND), an inventory simulation (SIMULATE), a game (PLAY), an editor (RENUMBER), and a mathematical programming program (MAX). All were initially programmed in BASIC on time-sharing systems using dialects developed by Dartmouth, Hewlett Packard, Digital Equipment, IBM, and University of Waterloo. Many of them now also run on microcomputers (IBM-PC, Apple, TI-99/4, and TRS-80).

A Proposal for a Standard UCL

The format of most commands illustrated above is

WORD/Q1/Q2/ . . . /Qm,P1,P2,. . .,Pn

where WORD is the command root (e.g., HELP, EXAMPLE, DISPLAY, or FIND), Q1, Q2, ..., Qm are command qualifiers (e.g., FREQUENCY, FILE, 6, and DUAL), and P1, P2 ..., Pn are command parameters (e.g., COMMANDS, FRENCH.DAT, RX:1930, and 96-100). The qualifiers, if any, are separated by slashes (/) and the parameters, if any, are separated by commas (,).

In the process of implementing my programs on the IBM-PC, I reviewed this command format and consulted with others on its possible generalization.

David Naddor, a software engineer in Atlanta, made the following suggestions:

- Either commas (,) or spaces ( ) should be accepted as parameter separators in the command (e.g., EXA DIS or EXA,DIS).

- If a qualifier or parameter contains a space ( ) or a comma (,), then it should start and end with a quote (e.g., "Thomas Jefferson").

- A quote is either the quotation mark (") or an apostrophe (') (e.g., FIND 'Doe, John', and FIN/OR "'", "'").

- If a closing quote is missing, then it is assumed to follow the last character of the command (as on the IBM-PC in the command RUN "UCL).

- Two or more consecutive spaces or commas, not within quotes, are considered as a single parameter separator.

A UCL Parsing Algorithm

David not only proposed these generalizations, but he also coded a routine for parsing any command in this UCL format and for checking it. Figure 1 lists the code and figure 2 gives several outputs using the code.

The variables in the code are the following:

L$ The command string to be parsed
NUM The number of separate strings in L$
C$() The array containing NUM separated strings
P A pointer to the next quote
Q$ The quotation mark (")
Q The location of the next quote
Q2 The location of the next apostrophe (')
D The location of the next separator
D2 The location of the next comma (,)
C$ The current quote symbol
S$ The current separated string

Most application programs should include a minimal set of seven command roots that will have universal meaning.

Figure 1: David Naddor's UCL Parsing Algorithm

```
3000 PRINT "Command line? ";:LINE INPUT L$:NUM=0:Q$=CHR$(34)
3100 P=1:IF L$="" THEN 3900
3200 Q=INSTR(P,L$+Q$ ,Q$ ):Q2=INSTR(P,L$+"'","'"):IF Q2<Q THEN Q=Q2
3300 D=INSTR(P,L$+",",","):D2=INSTR(P,L$+" "," "):IF D2<D THEN D=D2
3400 IF Q>=D THEN 3500
3410 C$=MID$(L$,Q,1):L$=LEFT$(L$,Q-1)+MID$(L$,Q+1):P=INSTR(P,L$,C$)
3420 IF P=0 THEN D=LEN(L$)+1 ELSE L$=LEFT$(L$,P-1)+MID$(L$,P+1):GOTO 3200
3500 S$=LEFT$(L$,D-1):L$=MID$(L$,D+1):IF S$>"" THEN NUM=NUM+1:C$(NUM)=S$
3510 GOTO 3100
3900 PRINT "NUM =";NUM:FOR I=1 TO NUM:PRINT I,C$(I):NEXT:PRINT:GOTO 3000
```

Figure 2: Input and Output Illustrations

```
Command line? TEST1/QUA1/QUA2/QUA3,PAR1,PAR2
NUM = 3
 1            TEST1/QUA1/QUA2/QUA3
 2            PAR1
 3            PAR2

Command line? TEST2/QUA1 PAR1 PAR2 PAR3,PAR4
NUM = 5
 1            TEST2/QUA1
 2            PAR1
 3            PAR2
 4            PAR3
 5            PAR4

Command line? "TEST 3" "PAR 1",'PAR 2' 'PAR 3'
NUM = 4
 1            TEST 3
 2            PAR 1
 3            PAR 2
 4            PAR 3

Command line? TEST4:FIND/OR NAME:"Thomas Jefferson" NAME:'Doe, John
NUM = 3
 1            TEST4:FIND/OR
 2            NAME:Thomas Jefferson
 3            NAME:Doe, John

Command line? TEST5     "'",,,'"""'    "No end
NUM = 4
 1            TEST5
 2            '
 3            """
 4            No end
```

The location of the next quote is found in line 3200. Note that if there is no next quote, then its location is assumed to be at the end of the command string. The location of the next separator is found in line 3300. If none is found, it is also assumed to be at the end of the string.

If a quote is found, then it is removed in line 3410 and the location of the pointer to the matching quote is ascertained. If found, then it is removed in line 3420 and the search continues for the next quote in line 3200. If a matching quote is not found then the separator is assumed to be at the end of the string (line 3420).

Whenever the location of the next separator (D) precedes that of the next quote (Q) (line 3400), or whenever there is no matching quote, then the current separated string, S$, is examined. If it is a null string (the case of two or more consecutive separators), then it is ignored. Otherwise, NUM is increased and C$(NUM) is determined (line 3500).

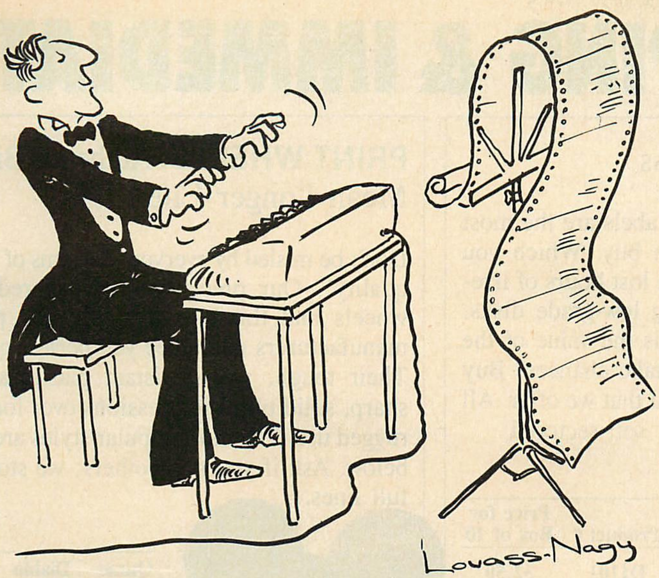
There are five illustrations of the algorithm in figure 2. In TEST1 the separator is the comma. In TEST2 it is either a space or a comma. In TEST3 we see how the quote is used and removed. Both the quotation mark and the apostrophe are illustrated.

TEST4 shows that the quote need not be at the beginning of a separated string. It also illustrates a case where there is no matching quote. Finally in TEST5 we see that several consecutive separators are considered as a single separator.

This elegant algorithm also shows the great power of BASIC's string handling capabilities.

A Minimal Set of UCL Command Words

Most application programs should



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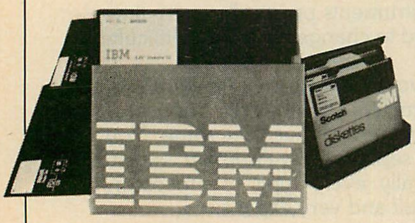

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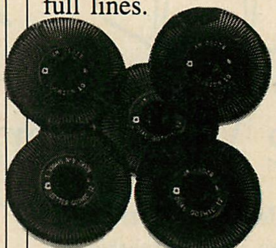

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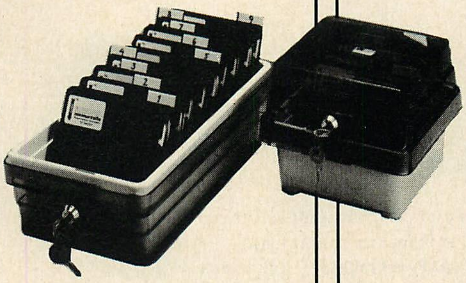

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Figure 3: The Commands HELP and EXAMPLE

```
UCL.BAS version 83/05/22

---------------------------------------------------------------------
[1] 05-22-1983 15:57:49                                          [1]
UCL? HELP

The available commands are:

COMPUTE   DISPLAY   EXAMPLE   HELP
GET       NEW       SAVE      STOP

(Use EXA ALL for detailed examples of all commands.)

---------------------------------------------------------------------
[2] 05-22-1983 15:57:51                                          [2]
UCL? EXA ALL

COM/ADD ROW 2,3 4    [Add rows 2 and 3 and put in row 4]
COM/DIV COL 3,1 6    [Divide column 3 by 1 and put in 6]]
COM/MAX ROW 5,4 6    [Put in row 6 the max of row 5 and 4]
 (Available operations: ADD, SUB, MUL, DIV, MIN, and MAX)

DIS ALL              [Display all elements]
DIS ELE 5,2          [Display element in row 5, column 2]
DIS,ROW 2-5          [Display elements in rows 2 to 5]
DIS,COL,7            [Display elements in column 7]
DIS ROW 2-4 COL 3-7  [Display rows 2 to 4, columns 3 to 7]
DIS FOR              [Display the current format]

EXA HEL              [Examples of the command HELP]
EXA NEW              [Examples of the command NEW]
EXA ALL              [Examples of all commands]

GET A                [Get data set A in DATA statements]
GET TAX.DAT          [Get data from file TAX.DAT]

HEL COM              [Show the names of all commands]
HEL ARI              [Describe the arithmetic operations]
HEL ALL              [Show all the HELP messages]

NEW ELE 3,2 7        [Set element in row 3 column 2  to 7]
NEW ELE              [Prompt for setting new elements]
NEW ROW 3-5          [Prompt for new elelments in rows 3 to 5]
NEW COL 1            [Prompt for new elements in column 1]
NEW ALL              [Prompt for all new elements]
NEW FOR ###.#        [New format is ###.##]
NEW FOR "#,###.##"   [New format is #,###.##}

SAV FINAL.DAT        [Save data in file FINAL.DAT]

STOP                 [Stop running of the program]
STO ABC              [Chain to program ABC]
---------------------------------------------------------------------
```

include a minimal set of seven command roots that will have universal meaning. They are as follows:

HELP, EXAMPLE, GET, DISPLAY, NEW, SAVE, and STOP.

HELP - Provides the names of all available command roots and an illustration of how to obtain examples of all commands.

EXAMPLE - Provides several illustrative examples of the precise format for the designated command root.

GET - Loads data into appropriate variables and/or arrays. The data may be in the DATA statements of the program or in a designated file.

DISPLAY - Outputs to the terminal designated portions of the data and/or results of computations.

NEW - Prompts the user for new data or for changes in portions of the current data.

SAVE - Saves the current data in a designated file. The format in which the data is saved must conform to the format used in reading the data with the command GET.

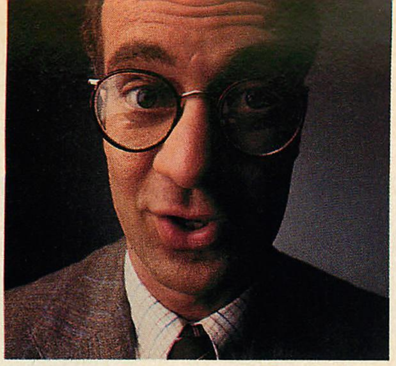
STOP - Terminates the running of the program and, optionally, chains to a designated new program.

I hope also that we can agree to use these precise words, just as the commands COPY,DIR, and RENAME seem to have become standard words for operating systems, and LIST, DELETE, and RENUM are standard commands in BASIC. In particular I would hope that HELP, EXAMPLE, and STOP be used as explained above.

I hope that we can agree to use these precise words, just as the commands COPY, DIR, and RENAME seem to have become standard words for operating systems, and LIST, DELETE, and RENUM are standard commands in BASIC.

To illustrate the use of UCL in a non-trivial application, I prepared a program called UCL.BAS, which includes some of the rudiments of a spread sheet. (The listing follows this article.) In addition to the seven standard commands proposed earlier, an eighth command, COMPUTE, is employed in the program. The heart of the application is a table with rows and columns. Values are initially placed in the table by means of the GET and NEW commands, and they can be shown on the terminal with DISPLAY.

The COMPUTE command allows arithmetic computations to be performed on two designated rows (or columns) and places the result in a designated row (or column). It



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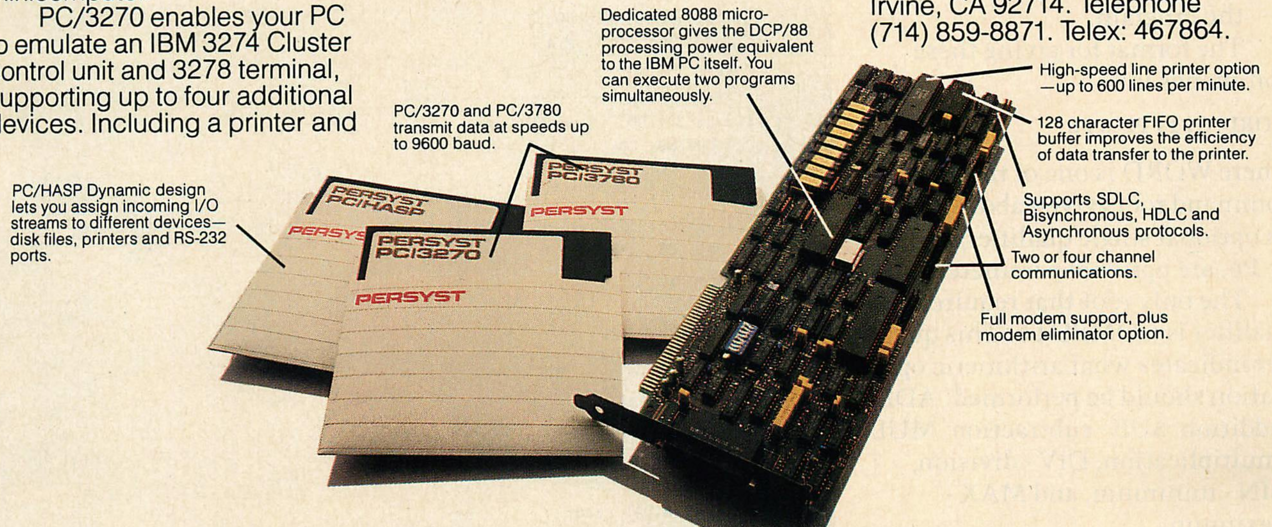

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requires one of six qualifiers that determine the desired operation: ADD - addition, SUB - subtraction, MUL - multiplication, DIV - division, MIN - minimum, and MAX - maximum.

The Commands in Program UCL.BAS

The set of command roots and their principal uses in UCL.BAS are the following:

COMPUTE - Carry out arithmetic computations using two designated rows (or columns) and place the results in a third designated row (or column)

DISPLAY - Display on the terminal the content of a designated range of rows and/or a designated range of columns.

EXAMPLE - Provide examples of the precise format of the designated command.

GET - Get a table of numbers currently in the DATA statements of the program or in a designated file.

HELP - Provide brief information on the designated topic.

NEW - Prompt for getting a new table, or for changing designated current rows (or columns).

SAVE - Save the current table of values in a format suitable for subsequent retrieval with the command GET.

STOP - Terminate the running of the program.

The format for giving these commands is

WORD/Q1 P1 P2 ... Pn

where WORD is one of the eight command roots given above, Q1 is an optional single qualifier, and P1, ..., Pn, are optional parameters.

The only root that requires a qualifier is COMPUTE. This qualifier indicates what arithmetic operation should be performed: ADD - addition, SUB - subtraction, MUL - multiplication, DIV - division, MIN - minimum, and MAX - maximum.

Figure 4:

The Commands GET, DISPLAY, COMPUTE, and SAVE (Set A)

```
[3] 05-22-1983 15:58:09                                          [3]
UCL? GET A
Data set A ready
---------------------------------------------------------------------
[4] 05-22-1983 15:58:15                                          [4]
UCL? DIS ALL

Data set = A  Rows = 3  Cols = 5  Title = Stores and items

   Col   1       2       3       5
Row
  1     20      35      12      59
  2      8      20       4      60
---------------------------------------------------------------------
[5] 05-22-1983 15:58:30                                          [5]
UCL? COM/ADD ROW 1,2,5
 Done
---------------------------------------------------------------------
[6] 05-22-1983 15:58:56                                          [6]
UCL? DIS,ROW 5

   Col   1       2       3       5
Row
  5     28      55      16     119
---------------------------------------------------------------------
[7] 05-22-1983 15:59:10                                          [7]
UCL? SAVE A.DAT
Data set A.DAT ready
```

Figure 5:

The Commands GET, DISPLAY, COMPUTE, and SAVE (Set B)

```
[8] 05-22-1983 15:59:33                                          [8]
UCL? GET B
 Data set B ready
---------------------------------------------------------------------
[9] 05-22-1983 15:59:41                                          [9]
UCL? DIS ALL
Data set = B  Rows = 4  Cols = 3  Title = Quantity, cost, price

   Col   1       2       3
Row
  1      3       4       7
  2      6      12.50   18
  3      3      25.35   35.75
  4     12      15      28.15
---------------------------------------------------------------------
[10] 05-22-1983 15:59:50                                        [10]
UCL? COM/MUL COL 1,2 4
 Done
---------------------------------------------------------------------
[11] 05-22-1983 16:00:21                                        [11]
UCL? COM/MUL COL 1,3 5
 Done
---------------------------------------------------------------------
[12] 05-22-1983 16:00:40                                        [12]
UCL? DIS COL 4-5

   Col   4       5
Row
  1     12      21
  2     75     108
  3     76.05  107.25
  4    180     337.80
---------------------------------------------------------------------
[13] 05-22-1983 16:00:57                                        [13]
UCL? SAVE B.DAT
 Data set B.DAT ready
```

Figure 6:
The Commands GET and DISPLAY (SETS A.DAT and B.DAT)

```
---------------------------------------------------------------------
[14] 05-22-1983 16:01:16                                        [14]
UCL? GET A.DAT

 Data set A.DAT ready
---------------------------------------------------------------------
[15] 05-22-1983 16:01:32                                        [15]
UCL? DIS ALL

Data set = A.DAT  Rows = 5  Cols = 5  Title = Stores and items

   Col   1      2      3      5
Row
  1     20     35     12     59
  2      8     20      4     60
  5     28     55     16    119
---------------------------------------------------------------------
[16] 05-22-1983 16:01:42                                        [16]
UCL? GET B.DAT

 Data set B.DAT ready
---------------------------------------------------------------------
[17] 05-22-1983 16:02:06                                        [17]
UCL? DIS ALL

Data set = B.DAT  Rows = 4  Cols = 5  Title = Quantity, cost, price

   Col   1      2      3      4      5
Row
  1      3      4      7     12     21
  2      6     12.50  18     75    108
  3      3     25.35  35.75  76.05 107.25
  4     12     15     28.15 180    337.80
---------------------------------------------------------------------
```

Figure 7:
The Commands NEW, FORMAT, COMPUTE, DISPLAY, and STOP

```
---------------------------------------------------------------------
[18] 05-22-1983 16:02:17                                        [18]
UCL? NEW,FOR "###,###.##"

 ###,###.## noted
---------------------------------------------------------------------
[19] 05-22-1983 16:02:45                                        [19]
UCL? COM/MUL COL 4,5 6

 Done
---------------------------------------------------------------------
[20] 05-22-1983 16:03:05                                        [20]
UCL? DIS COL 4-6

   Col       4          5          6
Row
  1         12         21        252
  2         75        108      8,100
  3         76.05     107.25   8,156.36
  4        180        337.80  60,804.00
---------------------------------------------------------------------
[21] 05-22-1983 16:03:10                                        [21]
UCL? STOP
---------------------------------------------------------------------
```

The number of parameters varies from command to command. COMPUTE requires four parameters; DISPLAY and NEW need one to four; EXAMPLE, HELP, and STOP may be used without parameters or with one parameter; and GET and SAVE need one parameter. The command EXAMPLE ALL gives examples of all command formats, exactly as the program expects them. It should be noted that parameters may be separated either by spaces or by commas, and that single or double quotation marks may be used when a space or a comma is part of a single parameter.

The following notation and conventions apply to program UCL.BAS.

The Table of Numbers - The value of the element of row R and column C is V(R,C). Rows range from 0 to R9 and the columns from 0 to C9.

Arithmetic Operations - When a command is given for computations involving rows R1 and R2, and the result to be put in row R3, then the program computes

V(R3,C) = V(R1,C) @ V(R2,C) for C = 1 to C9,

where @ depends on the designated qualifier (e.g., @ is + for ADD, it is * for MUL, and is the minimum operation for MIN). Similarly, for columns C1, C2, and C3 the computation is

V(R,C3) = V(R,C1) @ V(R,C2) for R = 1 to R9.

Row 0 and Column 0 - These are used only when the command DISPLAY is given. If V(R,0) equals zero, then the values V(R,C) are not displayed for all designated columns. That is, in this case the values of row R are not displayed. Similarly, if V(0,C) is zero, then the values in column C are not displayed.

Printing Format of Numbers - When values are displayed then integers are given without decimal points. Non-integers are displayed

Figure 8: File B. DAT

```
"B.DAT",4,5,"Quantity, cost, price"
1,1,1,1,1,1
1,3,4,7,12,21
1,6,12.5,18,75,108
1,3,25.35,35.75,76.05,107.25
1,12,15,28.15,180,337.8
```

Figure 9: Early Section of UCL.BAS

```
405 CO$="    COM DIS EXA GET HEL NEW SAV STO"
415 PO$="    ELE ROW COL ALL FOR"
425 FO$="###,###.######"
426 F1$="####.##"
427 F2$="####   "
```

Figure 10: Middle Section of UCL.BAS

```
  1015 ON 1+CO GOTO 900,1300,2700,1800,2000,1800,1200,2070,9999
  1020 REM          UCL COM  DIS  EXA  GET  HEL  NEW  SAV  STO

Since CO equals 6, the following statements are executed:

      1200 PO=INSTR(PO$," "+LEFT$(C$(2),3))/4
      1205 ON 1+PO GOTO 900,2100,2200,2300,2400,2600
      1210 REM          UCL ELE  ROW  COL  ALL  FOR

At this point, then, UCL.BAS proceeds to
      2600 T$=C$(3)
      2605 IF INSTR(FO$,T$)=0 THEN M$="Bad format" : GOTO 900
      2610 F1$=T$ : F2$=T$ : J=INSTR(T$,".")
      2615 IF J>0 THEN F2$=LEFT$(F1$,J-1)+SPACE$(LEN(F1$)-J+1)
      2620 M$=T$+" noted" : GOTO 900
```

according to a format specified by the user. Initially, the format (which is used by PRINT USING) is "####.##".

Illustrative Inputs and Outputs

Figures 3 to 8 give illustrations of several commands used in program UCL.BAS, and of the corresponding responses. All commands given are legal commands, otherwise the response is usually "Bad UCL".

Before prompting the user for a command, the program prints a panel number, a date, and the current time. In figures 3 to 7 we duplicated the panel number and added a dividing line between panels. These are not part of the output - they are provided only as an aid to the reader.

Panels [1] and [2] in figure 3 illustrate the commands HELP and EXAMPLE. In the examples note the use of the space character and the comma as separators. Also note the use of the quotation marks in the command NEW FOR "#,###.##". In the absence of these quotation marks, the command would have been interpreted as having four strings instead of the intended three.

Figure 4 shows several commands associated with data set A, which is in the DATA statements of UCL.BAS. Note that the elements in row 3 and in column 4 are not displayed, because V(3,0) and V(0,4) are both zero. The command in panel [5] causes the addition of the values in rows 1 and 2, and placement of the results in row 5, as can be verified in panel [6]. Finally, the new table of values is stored in file A.DAT (panel [7]).

Panels [8] to [13] of figure 5 deal with data set B, which is also in the DATA statements of UCL.BAS. Note how the values are printed in panels [9] and [12] - integers are printed without decimal points, and non-integers are printed with two digits after the decimal point. The multiplication of the respective columns can easily be verified (panels [9] to [12]).

The purpose of the illustrations in figure 6 is to show that the data stored earlier are correctly retrieved. Note the following convention used in UCL.BAS for the GET command: If the parameter does not include a period (.), then the set is assumed to be in DATA statements; but if a period is included, then the parameter signifies the name of a disk file. Incidentally, the content of the file B.DAT is given in figure 8.

In figure 7 we show how one can change the format for displaying numbers. Note that 76.05 * 107.25 equals 8156.3625 but is displayed as 8,156.36 because of the format specified in panel [18].

Some Coding Methods in UCL.BAS

A number of coding methods used in program UCL.BAS, described below, show how the program interprets the commands given by the user.

The user's command in panel [18] of figure 7 will be used as an illustrative example. In this panel the command is

NEW,FOR "###,###.##"

Using David Naddor's parsing algorithm UCL.BAS ascertains the values: C$(1) = "NEW",C$(2) = "FOR", and C$(3) = "###,###.##".

String constants are defined in an early section of UCL.BAS, as seen in figure 9. Where CO$ contains the command roots, PO$ contains parameter words, FO$ is for checking formats, F2$ is the initial format for integer values, while F1$ is for non-integers. After the user gives his command, the statement

1010 CO = INSTR9CO$," " + LEFT$(C$(1),3))/4

returns the value 6 for CO, which is used in the next step, shown in figure 10.

The T$ shown in figure 10 is a temporary variable which that "###,###.##". Because this string is within F0$, it is a legal format. Otherwise the user would have received the message "Bad format." Next a check is made to determine whether the desired format contains a period. If it doesn't, then both F1$ and F2$ are equated to T$. Otherwise (as in our example) F2$

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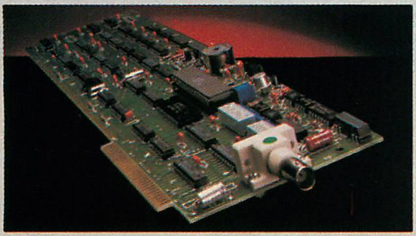

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is given the appropriate integer format.

And here is the coding for printing some value V (as in panel [20] of figure 7) which uses the formats F1$ and F2$:

```
2760 IF V=INT(V) THEN T$=F2$ ELSE T$=F1$
2762 PRINT USING T$;V;
```

Structure of Program UCL.BAS

The line numbers used in the coding discussed here follow a special structure, which I have found useful in many applications. It can be seen in the program UCL.BAS, which follows this article. The program listing is only a summary. The xxx stands for ADD, SUB, etc. More details on this structure and its application in a variety of diverse areas is the subject of another article.

LISTING UCL.BAS

Start	Command	Purpose
100		Preliminaries
200		User function
300		Dimensions
400		String constants
900		Message via M$
1000		User command
1200	NEW	New data or change in data
1300	COMPUTE	Arithmetic computations
1700	HELP	Brief helpful information
1800	EXAMPLE	Examples of commands
2000	GET	Get data set
2070	SAVE	Save data set
2100	NEW ELEMENT	Prompt for new value(s) of element(s)
2200	NEW ROW	Prompt for new values of row(s)
2300	NEW COLUMN	Prompt for new values of column(s)
2400	NEW ALL	Prompt for a new data set
2600	NEW FORMAT	Change format
2700	DISPLAY	Display value(s) of data
3100	COM/xxx ROW	Do type xxx computations on rows
3200	COM/xxx COLUMN	Do type xxx computations on columns
9400		Extract qualifier
9600		Parsing algorithm
9700		Panel, date, and time
9800		Error routine
9900		DATA statements
9999	STOP	Terminate running or chain

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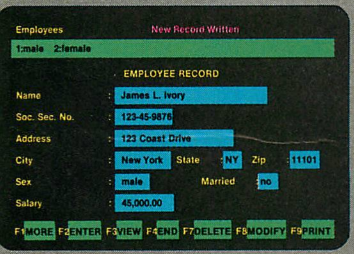

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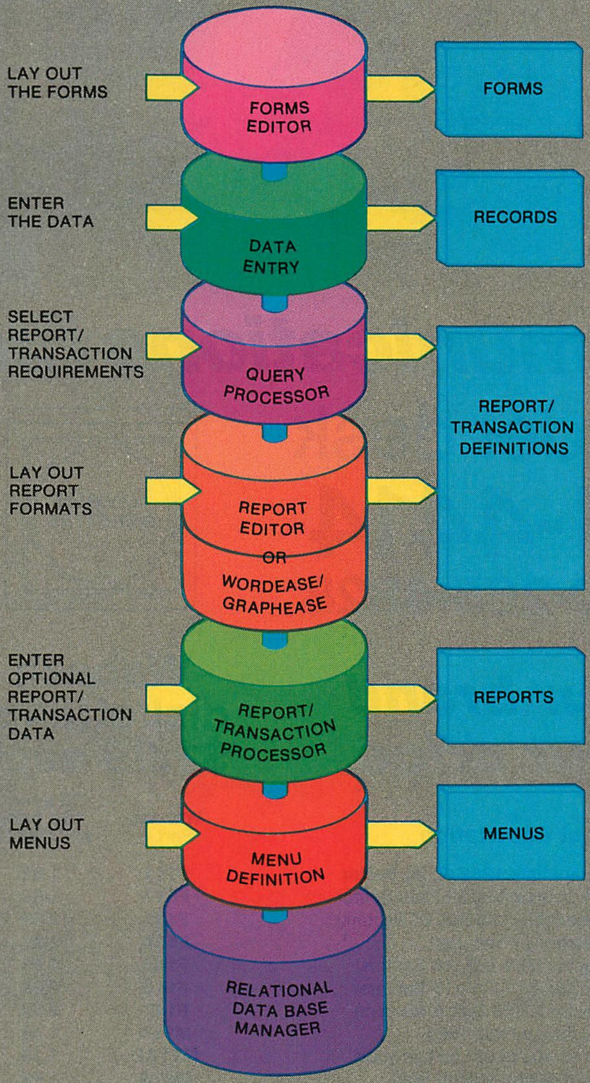

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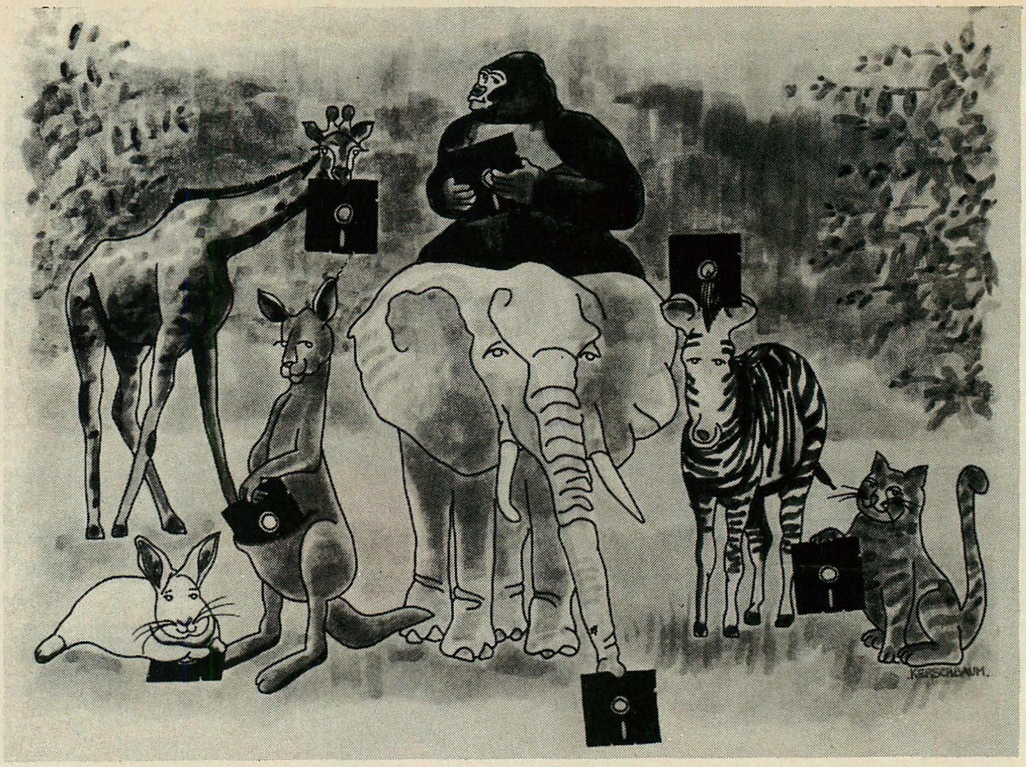

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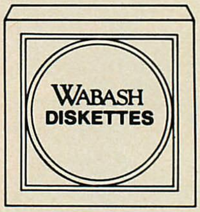

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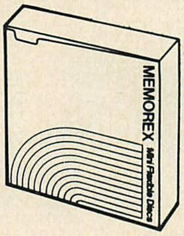

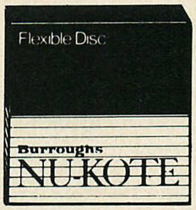

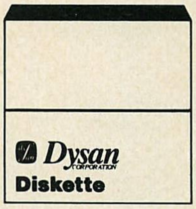

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——	——
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——	——
——	——
——	——
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——	——
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An Inside Look at Microsoft Basic on the IBM PC

Knowing how BASIC does what you tell it to do will help you write faster BASIC programs and build powerful programming tools.

ROBERT METZGER

Everyone likes to get the inside story on an interesting subject. BASIC users are no exception. While this article won't present stolen documents from IBM or MicroSoft, it will present the fruits of careful detective work. If you're interested in knowing how BASIC does what you tell it to, read on. Not only will you satisfy your curiosity, you'll learn how to write faster BASIC programs and build powerful programming tools as well. And if you are looking for a real scoop, you will find the very first announcement of four features that probably will be in the next release of MicroSoft BASIC on the IBM PC.

What is BASIC? It's a family of related programming languages. The version used on the IBM PC is just one of many BASIC dialects. How do you use BASIC? You must have your BASIC program translated from the version of BASIC you are using into instructions that your machine can execute. In the case of the IBM PC, that means the machine language of the Intel 8088 processor. This article explains how one BASIC-to-8088 translator works.

COMPILERS VERSUS INTERPRETERS

There are two kinds of programs that translate from one programming language to another: compilers and interpreters. Actually, today's pure compilers and pure interpreters are endangered species. Many translators are hybrids, either mostly compiler or mostly interpreter. IBM provides both an interpreter and a compiler for BASIC on the PC. In this article we will explore how the BASIC interpreter works.

The difference between an interpreter and a compiler is that, al-

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IBM
Personal Computer

though they both translate your BASIC program into 8088 machine code, an interpreter takes one statement at a time, translates it, and executes it, while a compiler translates all of the statements at once.

Interpreters and compilers each have advantages and disadvantages. When a program line is not often executed, compiling is no more efficient than interpreting. On the other hand, if the same program line is executed over and over, the total number of machine instructions is minimized by compiling. The reason that compiled code runs faster is that the repetitive translation is eliminated.

The main purpose of the lexical scan is to break up the text into "atoms" or "tokens." A token can be a keyword (like PRINT), a number (like 123), and so on. Tokens are groups of characters that form a logical unit.

Interpreters have two other major advantages. They are a lot easier to write than compilers. This fact is reflected in the difference in prices IBM charges for the BASIC interpreter and compiler. The best reason to use an interpreter is that it makes program development much easier.

How Basic Executes Statements

As explained above, the BASIC interpreter translates one statement at a time and then executes it. Actually, the translation is done in two steps. When you type in a program, preliminary processing is done to make the actual translation process run faster. This preliminary work is often called the "lexical scan" (the root lex refers to words, and this scan looks for words).

How do we know that Microsoft BASIC does a lexical scan? If we use PEEK to display a program text that is stored in memory, it does not look like what you have typed in. The variable names and remarks are there, but just about everything else is changed. More about this later.

The main purpose of the lexical scan is to break up the text into "atoms" or "tokens." A token can be a keyword (like PRINT), a number (like 123), and so on. Tokens are groups of characters that form a logical unit.

After you have typed a line, the computer goes through your entry character by character from left to right. When a word is found, it is looked up in a table to determine whether it is a keyword. If it is, it is replaced with a special byte. If a number is found, the interpreter determines whether it is an integer, single-precision, or double-precision number and converts it to the internal representation of that form. Many interpreters place variable names in a special table, and replace the name in the text with a pointer to the table. The PC interpreter leaves variable names alone and stores them directly with the value of the variable when it is assigned.

The lexical scan uses a technique known as "transition diagrams" or "finite state machines" to analyze the text. The difference between the two is mostly whether you like to draw tables or networks. I will discuss finite state machines, but the same principles apply if you draw diagrams.

Figure 1: Sample Finite State Machine to Scan Numbers

INPUTS	STATES Start	Whole	Part	Sign	Power	Nosign	Constant
digit	whole	whole	part	whole	power	ERROR	constant
.	part	part	ERROR	part	ERROR	ERROR	ERROR
+ -	sign	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR
D E	ERROR	power	power	ERROR	ERROR	ERROR	ERROR
% ! #	ERROR	OK	OK	ERROR	OK	ERROR	ERROR
&	Nosign	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR
H O	ERROR	ERROR	ERROR	ERROR	ERROR	constant	ERROR
end	ERROR	OK	OK	ERROR	OK	ERROR	OK

The initial state is Start. If the string "-12.34E6" is analyzed using this table, the process will go as follows.

STATE	INPUT	NEW STATE
Start	-	Sign
Sign	1	Whole
Whole	2	Whole
Whole	.	Part
Part	3	Part
Part	4	Part
Part	E	Power
Power	6	Power
Power	END	OK

The technique is both simple and powerful. The computation is represented by a table in which the rows refer to classes of inputs characters, and the columns refer to states. The computation begins in a pre-defined initial state. It processes inputs one at a time by selecting the position in the table corresponding to the current state and the new input. That position in the table will specify what state to go to next, and what action to take, if any. If the diagram approach is used, the inputs are nodes, the state changes are arcs, and actions can be associated with the arcs.

The finite state machine shown in figure 1 will correctly analyze strings that represent numeric constants. The entire lexical scan table is, of course, much bigger.

When you have finished typing your program, you are ready to run it. Now the interpreter will make a syntax analysis pass through each line as it is executed. Lines that are not executed do not go through syntax analysis, and those that are executed more than once go through it every time they are executed. Once again the interpeter goes through the text of the line (now in internal form) byte by byte, from left to right. When the syntax analyzer finds an operation to perform (like adding two numbers), it calls a subroutine to do the work. This is quite different from a compiler, which usually generates actual machine instructions as it identifies operations. But because most compilers are actually hybrids, some operations are set up as subroutine calls to the run-time library of standard subroutines.

It would be possible to disassemble the machine code of the BASIC interpreter, and reconstruct the exact finite state machines or tran-

sition diagrams used for lexical and syntax analysis. But because the practical benefits of such an analysis are hard to see, the remainder of this article concentrates on areas that can be applied to constructing programs.

How Data Is Stored

Now we need to look at how things are actually stored by BASIC. The architecture of the 8088 processor divides memory up into 64K segments. The interpreter is in one segment, your program in another. The implementers of this BASIC chose to use these limits as a part of the design of their program. This is the reason that BASIC can't make use of more than 64K of RAM, regardless of much memory you actually have on your machine.

Within the segment devoted to your program, are seven areas:
1) *interpreter work area,*
2) *actual program text,*
3) *scalar variables,*
4) *array variables,*
5) *free space,*
6) *string space,*
7) *execution stack.*

We will discuss each of these in turn, leaving program storage for last, as it is the most complicated.

The interpreter work area, shown in figure 2, contains a lot of miscellaneous data needed for the intepreter to operate. Some of the values it contains are listed below.

Figure 2: Interpreter Work Area

	OFFSET	LENGTH
Line number currently being executed	02E	2
Line number of last error	347	2
Keyboard buffer empty?	06A	1
Random seed	F79	2

The interpreter work area (see figure 3) also contains pointers that define the start and end of all other areas. To see the actual values of these pointers (which change during program execution), you can use the function
DEF FNPTR(X) = PEEK(X) + 256∗PEEK(X + 1).
For example, PRINT FNPTR (&H30) shows the location of the beginning of the program text.

Figure 3: Pointers in the Interpreter Work Area

Pointer Stored at	Points to
030 (HEX)	start of program text
356	end of program text
358	start of scalar variables
35A	start of array variables
35C	start of free space
32F	end of string space
30A	start of string space
02C	end of execution stack
	(start of execution stack is always the highest memory location in BASIC's segment, unless altered by CLEAR)

The scalar area contains all variables without dimensions. The variables are stored in the order that they are assigned. The first to be assigned is at the beginning of the scalar area, the last to be assigned is at the end. The amount of space used by the variable depends on its data type and the length of its name.

Figure 4: Fields in a Scalar

Field Size in Bytes	Contents of Field
1	Data Type
2	First two letters of name
1	Count of additional letters in name
0 to 38	Remaining letters in name
2 to 8	Value of variables Integer - 2 bytes String - 3 bytes Single - 4 bytes Double - 8 bytes

The first three fields in a scalar entry (figure 4) have the same length, regardless of the data type and name. The data type byte is the same as the number of bytes needed to represent the value, i.e., data type 2 is integer.

How are the data values represented? Integers are stored with the less significant byte at the lower address. Fifteen bits are used to store the number, and one is used to store the sign.

Strings are not actually stored in the scalar area. Instead, one byte indicates the length of the string, and two bytes are used to point to the value of the string in the string space. Because only one byte is used to store the string length, strings can only be up to 255 characters long.

Single and double precision floating point numbers have essentially the same format, although double precision allows more digits to be represented. The exponent of the floating point number is stored at the highest (right-most) address. The exponent is stored as an unsigned integer ranging from 0 to 255. To get the actual exponent, subtract 128. The fraction is stored with the bytes of least significance at the lowest (right-most) address. The sign of the fraction is the leftmost bit in the right-most byte of the fraction. Twenty three bits are available in double precision.

The following example illustrates the way scalar variables are stored. Figure 5 shows a BASIC statement and the resulting scalar area after its execution. Note that the type indicator suffixes (i.e., per-

The architecture of the 8088 processor divides memory up into 64K segments. The interpreter is in one segment, your program in another. This is the reason that BASIC can't make use of more than 64K of RAM.

cent) are not stored in the scalar area, but rather in the program text. Also, the letters after the first two are stored as 128 plus their ASCII values.

The array variable comes immediately after the scalar variables area. This means that every time a new scalar is created, the entire array area has to be moved to make room. The values of the elements of an array are stored in the same way

Figure 5: Storage of Scalar Variables

The values are listed in hexadecimal, and are explained in the following diagram.

```
024100007B00 03424200035310
04434301C300007687 08444402C4C40000000000007687
```

Type	Name	Extra Letters	Rest of Name	Value	--or--	String Length	String Pointer
02 integer	4100 A	00		7B00			
03 string	4242 B B	00				03	5310
04 single	4343 C C	01	C3 C	00007687			
08 double	4444 D D	02	C4C4 D D	0000000000007687			

Figure 6: Array Variable

Field Size in Bytes	Contents of Field
1	Data type
2	First two letters of name
1	Count of additional letters in name
0 to 38	Remaining letters in name
2	Number of bytes use to store this array
1	Number of dimensions
2	Length of each dimension (2 bytes per dimension)

Figure 7: Beginning Memory Entry

Name	Type	Extra Letters	Bytes Stored	No. of Dims.	3rd Dim.	2nd Dim.	1st Dim.
4142 A B	02 int	00	7F00	03	0500	0400	0300

as those of scalars. But extra information must also be stored. Figure 6 shows the structure of an array.

The dimension lengths are stored backwards, i.e., from the right-most to the left-most. The elements follow the dimension lengths. They are stored in column major order. This means that all of the elements of a given column will be next to each other in memory. Then all of the columns of a given plane will be next to each other, and so on.

If we created an array with DIM AB%[3,4,5] and assigned it values, the beginning of its memory entry would look like figure 7.

While new scalar and array definitions reduce free space from the low address end of BASIC's memory segment, new string definitions reduce the free space from the opposite direction. Strings are added as they are used until all the free space is gone. Then BASIC attempts to create free space by removing all the strings that are no longer pointed to by scalar or array variables. This is what computer scientists commonly refer to as garbage collection.

The execution stack keeps track of subroutine calls and related matters, which put a process on hold. Use of GOSUB, FOR-NEXT, and PAINT will put entries on this stack. If the stack space is exhausted, the message OUT OF MEMORY is entered. Use the CLEAR statement to increase the size of the stack if necessary. The default size is 512 bytes.

How Programs Are Stored

Each program line begins with a delimiter byte. This is always an ASCII 0, except for the first line of the program. Here it is ASCII 255 (&HFF) if the program is not protected, and ASCII 254 (HFE) if it is protected. The remainder of a protected program is encrypted when it is on diskette, but follows the format described below when it is in memory. Following the delimiter byte comes a 2-byte integer, which points to the delimiter byte that starts the next statement. After the forward pointer comes the line number, also stored as a 2-byte integer. Both of these numbers are in the low-byte first, high-byte last order used by the 8088. The last part of the line is the statement text,

Figure 8: Changes Made in First Lexical Scan

1) Convert lower case letters to upper case.

2) Convert keyword names (like PRINT) to 1 byte tokens, including a prefix byte where necessary.

3) Convert symbolic operators (like + or =) to 1 byte tokens.

4) Convert numeric constants (like 1.234) to the proper internal representation, including a prefix byte where necessary. The following forms are used.

CONSTANTS	INTEGERS	FLOATING POINT
single decimal digit	line numbers	single precision
single byte	hex or octal	double precision
	decimal	

Figure 9: Commonly Used Initializations

```
10 DEFINT A-Z:DEF SEG:OPTION BASE 1
20 SCREEN 2:OUT &H985,12:KEY OFF:CLS
```

Hex	ASCII	Meaning	Hex	ASCII	Meaning
FF		start program	00		start line
5810		next line pointer	7410		next line pointer
0A00		line 10	1400		line 20
AD		token DEFINT	C8		token SCREEN
20	blank		20	blank	
41	A		13		number 2
EA		token -	3A	:	
5A	Z		9C		token OUT
3A	:		20	blank	
97		token DEF	0C		hex constant
20	blank		8509		985H
534547	SEG		2C	,	
3A	:		0F		1 byte number
B8		token OPTION	0C		12
20	blank		3A	:	
42415345	BASE		C9		token KEY
20	blank		20	blank	
49	1		DD		token OFF
			3A	:	
			C0		token CLS

Table 1: Internal Representation of BASIC Statements

Value	Meaning	Note
0-9,16,27,30	no meaning[a]	
10,13	Line Feed, New Line[a]	
11	prefix for 2 byte octal constant	
12	prefix for 2 byte hexadecimal constant	
14	prefix for 2 byte line number	
15	prefix for 1 byte decimal constant	
17-26	single decimal digit constant	
28	prefix for 2 byte integer	
29	prefix for 4 byte floating point	
31	prefix for 8 byte floating point	
32,44,58,59	delimiters: blank , : ;	
33,35-38	data type indicators: ! # $ % &	
34	quote begins string constants	
39	apostrophe[b]	
40,41,91,93	parentheses and brackets ( ) [ ]	
42,43,45,47, 60-62,92,94	arithemetic and comparison operators:[c] * + - / < = > \ ^	
46	period (in names only)	
48-57	digits: 0123456789[c]	
63,64,95,96, 123-127	unused characters:[d] ? @ _ ` { | } ~ delete	
65-90	upper case letters: A-Z	
97-122	lower case letters: a-z[d]	
128-255	keyword tokens and prefix bytes	

[a] *These will never occur in the internal representation.*

[b] *Apostrophe beginning a remark is converted to a colon followed by the REM keyword byte, but is still displayed as an apostrophe.*

[c] *These will only appear with this value in DATA statements, remarks, and string constants, and a few odd statements like OPTION.*

[d] *These can only occur in DATA statements, remarks, and string constants.*

Table 2: Cassette BASIC Commands, Statements, Keywords, Functions, Operators

			160	A0	WIDTH	192	C0	CLS	224	E0	
129	81	END	161	A1	ELSE	193	C1	MOTOR	225	E1	
130	82	FOR	162	A2	TRON	194	C2	BSAVE	226	E2	
131	83	NEXT	163	A3	TROFF	195	C3	BLOAD	227	E3	
132	84	DATA	164	A4	SWAP	196	C4	SOUND	228	E4	
133	85	INPUT	165	A5	ERASE	197	C5	BEEP	229	E5	
134	86	DIM	166	A6	EDIT	198	C6	PSET	230	E6	>
135	87	READ	167	A7	ERROR	199	C7	PRESET	231	E7	=
136	88	LET	168	A8	RESUME	200	C8	SCREEN	232	E8	<
137	89	GOTO	169	A9	DELETE	201	C9	KEY	233	E9	+
138	8A	RUN	170	AA	AUTO	202	CA	LOCATE	234	EA	-
139	8B	IF	171	AB	RENUM	203	CB		235	EB	*
140	8C	RESTORE	172	AC	DEFSTR	204	CC	TO	236	EC	/
141	8D	GOSUB	173	AD	DEFINT	205	CD	THEN	237	ED	^
142	8E	RETURN	174	AE	DEFSNG	206	CE	TAB(	238	EE	AND
143	8F	REM	175	AF	DEFDBL	207	CF	STEP	239	EF	OR
144	90	STOP	176	B0	LINE	208	D0	USR	240	F0	XOR
145	91	PRINT	177	B1	WHILE	209	D1	FN	241	F1	EQV
146	92	CLEAR	178	B2	WEND	210	D2	SPC(	242	F2	IMP
147	93	LIST	179	B3	CALL	211	D3	NOT	243	F3	MOD
148	94	NEW	180	B4		212	D4	ERL	244	F4	\
149	95	ON	181	B5		213	D5	ERR	245	F5	
150	96	WAIT	182	B6		214	D6	STRING$	246	F6	
151	97	DEF	183	B7	WRITE	215	D7	USING	247	F7	
152	98	POKE	184	B8	OPTION	216	D8	INSTR	248	F8	
153	99	CONT	185	B9	RANDOMIZE	217	D9	'	249	F9	
154	9A		186	BA	OPEN	218	DA	VARPTR	250	FA	
155	9B		187	BB	CLOSE	219	DB	CSRLIN	251	FB	
156	9C	OUT	188	BC	LOAD	220	DC	POINT	252	FC	
157	9D	LPRINT	189	BD	MERGE	221	DD	OFF	253	FD	***
158	9E	LLIST	190	BE	SAVE	222	DE	INKEY$	254	FE	***
159	9F		191	BF	COLOR	223	DF		255	FF	***

modified as described below.

When BASIC performs the first (lexical) scan of the line, it makes the changes shown in figure 8 to those portions of the text that are not part of a remark, a string constant, or a DATA statement. Table 1 lists the meaning of each possible ASCII value when it is found in the internal representation of a BASIC statement. Tables 2, 3, and 4 give the keyword interpretations of the one and two-byte tokens. The short program shown in figure 9 illustrates some commonly used initializations. Many of the features of program storage are demonstrated. The internal representation of the program is listed below it.

Table 3: Cassette BASIC Functions

129	81	LEFT$	142	9E	ATN	154	AA	HEX$
130	82	RIGHT$	143	9F	FRE	155	AB	LPOS
131	83	MID$	144	A0	INP	156	AC	CINT
132	84	SGN	145	A1	POS	157	AD	CSNG
133	85	INT	146	A2	LEN	158	AE	CDBL
134	86	ABS	147	A3	STR$	159	AF	FIX
135	87	SQR	148	A4	VAL	160	C0	PEN
136	88	RND	149	A5	ASC	161	C1	STICK
137	89	SIN	150	A6	CHR$	162	C2	STRIG
138	9A	LOG	151	A7	PEEK	163	C3	EOF
139	9B	EXP	152	A8	SPACE$	164	C4	LOC
140	9C	COS	153	A9	OCT$	165	C5	LOF
141	9D	TAN	154	AA	HEX$			

How to Investigate the Interpreter

How did I find the information presented in this article? It really wasn't very hard. I began by reading the documentation on the internals of BASIC provided by the IBM manuals. Pages i-2 through i-5 in the BASIC manual and page 3-23 of the technical reference provided some useful data on the way basic uses memory. I also reviewed two books on the subject so I would know what to be looking for. *Writing Interactive Compilers and Interpreters* by P. J. Brown (Wiley, 1979) was quite helpful. *Implementing BASICS* by William and Patricia Payne also provided useful information.

Next, I wrote a program that would dump a BASIC program stored on a diskette to a printer. What I needed to see were the numerical values of each byte, as well as the ASCII character that corresponded to it. I wanted both decimal and hexadecimal numbers in order to spot relationships more easily. The program I wrote is shown in listing 1. It prints the information for 8 bytes on each line. The ASCII character is listed only if it is printable (i.e., its ASCII value is greater than 31).

Once I finished my program, I ran it with a number of program files and started to inspect carefully the output. I followed the standard form of inductive reasoning: Inspect the data, organize the data, devise a hypothesis, prove the hypothesis. Inductive reasoning (working from particular facts to general conclusions) is an important part of the debugging process. In my case, of course, I had many hypotheses to devise and prove regarding different aspects of how

Proving (or disproving) a hypothesis is no less important than the other step; programmers doing debugging sometimes slight it.

BASIC programs are stored.

Proving (or disproving) a hypothesis is no less important than the other steps, though programmers doing debugging sometimes slight it. The steps I took varied with the hypothesis. In the case of BASIC's reserved words, once I decided that they were stored as a single byte, and could have a prefix, I used the program listed in listing 2. It's a rather odd bird: a self-modifying program. If you RUN it, and then LIST it, you will see that line 180 will be transformed from a long literal to a rather nonsensical line. That line will contain all the reserved words related to a given prefix byte. The PREFIX variable set on line 110 can be changed to suit your needs. Tables 1 through 4 were developed using this program. (Note

Table 4: Disk and Advanced BASIC

STATEMENTS		FUNCTIONS
129 81 FILES	144 90 COM	129 81 CVI
130 82 FIELD	145 91 CIRCLE	130 82 CVS
131 83 SYSTEM	146 92 DRAW	131 83 CVD
132 84 NAME	147 93 PLAY	132 84 MKI$
133 85 LSET	148 94 TIMER	133 85 MKS$
134 86 RSET	149 95 IOCTL	134 86 MKD$
135 87 KILL	150 96 MKDIR	
138 PUT	151 97 SHELL	
137 89 GET	152 98 VIEW	
138 8A RESET	153 99 PMAP	
139 8B COMMON	154 9A ERDEV	
140 8C CHAIN	155 9B CHDIR	
141 8D DATE$	156 9C RMDIR	
142 8E TIME$	157 9B ENVIRON	
143 8F PAINT	158 9E WINDOW	

1. *Values 253, 254, and 255 in table 2 are prefix bytes. This means that when BASIC encounters one of them, it knows it must interpret the following byte in a special way.*

253 means that the next byte denotes a Disk or Advanced BASIC function (table 4).
254 means that the next byte denotes a Disk or Advanced BASIC keyword (table 4).
255 means that the next byte denotes a Cassette BASIC function (table 3).

2. *Cassette BASIC statements and commands have values 129-202. As the BASIC manual says, "The distinction between a command and a statement is largely a matter of tradition." They are distinguished from keywords, functions, and operators in that statements and commands can begin a BASIC expression, but the other three cannot. Some statements can also be keywords (INPUT, KEY, ON). ELSE is a hybrid between a statement and a keyword, but is included in the statement category.*

3. *Cassette BASIC keywords have values 204-210,215,221. These words are always part of an expression begun with a statement.*

4. *Cassettte BASIC operators have values 230-244. In BASIC the distiniction between operators and functions is based on whether the operands are placed between the symbol (operator) or after the symbol, enclosed in parentheses (function).*

5. *Some Cassette BASIC functions are in table 2, others in table 3. With the exception of LEFT$, RIGHT$, and MID$, all functions in table 3 take one argument and return one result. This explains why FRE and POS must be given dummy arguments. It does not explain why they were put in this class. A possible explanation is that a future version of BASIC will attach meanings to the argument. The precedent is LPOS, whose argument in Cassette BASIC is a dummy, but which has meaning in Disk or Advanced BASIC.*

6. *The functions in table 2 are a varied lot. Some take no arguments (ERL, ERR, CSRLIN, INKEY$), others one argument (VARPTR), or two arguments (STRING$, INSTR, POINT). Also included in this section of this table is that anomalous operator NOT, which only needs one operand.*

7. *There are several keywords which differ only in a trailing special character.*

INPUT	*PRINT*	*VARPTR*	*WRITE*
INPUT$		*VARPTR$*	
INPUT#	*PRINT#*		*WRITE#*

As you can see from table 2, there are not separate entries for each of these words. Instead, the word is stored as one byte, and the special character is a second byte. This explains why BASIC does not allow you to use names of your own which only differ from a reserved word by a trailing special character.

8. *The special words that are not stored with a 1–byte token (AS, SEG, BASE) are stored just like variable names.*

9. *Note that there are four statements which are totally undocumented in the BASIC manual revisions for DOS 2.0:*
ERDEV, IOCTL, SHELL, ENVIRON
These work NOW, and will probably be an official part of the next release of BASIC. You read it here first!

ENVIRON is the BASIC analog to the DOS 2.0 SET command. Try ENVIRON("COMSPEC= A: COMMAND.COM") and read about it on page 10-21 of the DOS manual.

SHELL is the BASIC analog to the DOS configuration command of the same name. Try SHELL ("A: COMMAND.COM"). You can read more about it on page 9–10 in the new DOS manual.

IOCTL is the BASIC analog to the DOS function 44H, which is called with interrupt 21H. Try IOCTL(filenum) = value. You can read about the DOS version on page D-39 of the DOS 2.0 manual.

ERDEV is a new event class. Try ON ERDEV GOTO 20. The name probably stands for DEVice ERror, and I expect it to be used together with IOCTL. Since each of these commands is undocumented, and may have unwanted side effects, I recommend caution in using them.

that you may want to increase the BASE variable on line 210 to get past the DATA and REM reserved words, if PREFIX = 32.)

The suggestions in the section on optimizing programs started out as hunches. They too had to be verified. My approach was simple: Take a set of statements and write them using the suggestion, and not using it; then run each of these two sets of statements a number of times and keep track of the time required to execute them. I used the program shell listed in listing 3 to do this. This program outline can be used for timing any pair of algorithms.

How to Optimize Basic Programs

In general, a more concise program will run faster. Obviously, there are lots of cases where a totally different approach to a program, although it results in a longer program, will run more quickly. Even so, to optimize the performance of a program, one important consideration is minimizing the number of characters that BASIC must interpret. Note that the object is to minimize the number of characters in the internal representation of the program, not simply the number of characters displayed by LIST.

An important method for increasing efficiency is to search for algorithms that do less work. *Writing Efficient Programs* by Jon Smith (Prentice Hall, 1982) is an excellent resource for learning how to do this.

Another method is to exploit special knowledge about the execution behavior of the interpreter, or of the hardware. The BASIC manual suggests using integer counters for FOR-NEXT loops. In order to make such suggestions, you must understand the architecture of the hardware, and the way particular parts of the interpreter are implemented. While this information is helpful, it cannot be developed by the methods I have used in this article. What follows in this section is

information on how to optimize programs based on knowledge about the way programs are stored and interpreted.

> *There is one suggestion for optimizing BASIC programs listed in the BASIC manual that does not yield any time savings: "Combine statements where convenient to take advantage of the 255 character statement length."*

While the following methods yield some marginal performance improvements, they also reduce the readability of the program.

1. Omit unnecessary blanks. Blanks before and after delimiters like () [] , ; : and operators like + − * \Λ ‡ ⟨ ⟩ can safely be omitted.

2. Omit unnecessary parentheses. Make sure that you understand the precedence rulers of BASIC.

3. Convert relational operators written with two symbols into their single symbol opposites. This can be done by inverting tests and branching on false conditions, rather than true ones.

Symbol Pair	Opposite
=⟨ ⟨=	⟩
=⟩ =⟩	⟨
⟨⟩ ⟩⟨	=

4. Reduce Boolean expressions to their simplest form. DeMorgan's laws can be used to distribute the negation NOT over AND and OR.

Expression	Equivalent
(NOT X) AND (NOT Y)	NOT X OR Y
(NOT X) OR (NOT Y)	NOT X AND Y

5. Use shorthand notations
a) "LET" is unnecessary in assignment statements.
b) "#" is not needed in front of a file number when using statements like CLOSE and FIELD
c) The loop counter does not need to be included in a "NEXT" statement.

6. Use variable names of two characters or less.

7. If a value is truly constant, use a constant rather than assign it to a variable. Constants are directly accessible in the program text, but variables must be searched for in the scalar or array areas.

8. Assign data to variables directly, rather than use READ and DATA if the data will be read repeatedly. Constants are converted to internal form when you enter the program, but numbers in DATA statements are converted each time they are READ.

9. Assign variables in the order of their frequency of use. Putting the most used variables first minimizes the time spent searching the scalar and array areas.

10. Use the single quote (') to place remarks at the end of a line rather than using a separate statement.

Micro Mythology

There is one suggestion for optimizing BASIC programs listed in the BASIC manual that does not yield any time savings: "Combine statements where convenient to take advantage of the 255–character statement length." The evidence just doesn't support this advice.

How to Create Self-Modifying Programs

As it stands, BASIC only allows numbers and strings as responses to INPUT and LINE INPUT. There are circumstances in which it is desirable to allow the user to enter BASIC statements that will be evaluated by the program. Given the information presented in this article, you can do just that.

What would you use such a feature for? What if you were writing a plotting package and wanted to allow the user to specify an equation to plot? Or if you were developing a financial analysis package and wanted to allow the user to specify how certain values were to be calculated?

The program in listing 4 implements this idea. It takes a literal string as input. This string should be a valid BASIC statement. The statement can contain parentheses, arithmetic operators (+ − * / \ ^), numeric constants, and 10 arithmetic functions (SGN,ABS,INT,SQR,EXP,LOG,SIN,COS,TAN,ATN). The string is transformed into the internal representation of the statement. It is then poked into the definition of a defined function, which can be evaluated as often as needed.

How to Create Powerful Programming Tools

The prograam that allows a user to enter BASIC expressions as input writes BASIC programs in their internal format. There are a number of programming tools that read BASIC programs in their internal format. Because programs can be saved in ASCII format, why do this? There are two reasons: ease of use and efficiency.

By writing programming tools that work directly on BASIC programs in internal format, you

> *A little bit of esoteric knowledge can be put to quite practical use in programming the IBM PC in BASIC. This article has given you the tools for exploring the interpreter further on your own if you choose.*

eliminate the extra steps of loading the program, saving a second copy in ASCII format, and deleting the extra copy when done. BASIC has already done a lot of processing for you. The text is more compact, so less data needs to be processed. The keywords have already been located, so you don't need to look them up in a table. The line numbers have been distinguished from nu-

meric constants, and string constants. You may choose to list any combination of these. After initializing, the program asks you for the name of the file you want to work on. Then it analyzes the text, printing out the number of the line being processed as it goes. The sorting is done with the Quicksort algorithm. The printout shows the objects you requested, along with the line numbers on which they occur.

SUMMARY

A little bit of esoteric knowledge can be put to quite practical use in programming the IBM PC in BASIC. This article has given you the tools for exploring the interpreter further on your own if you choose. This implementation of BASIC serves its users well. Now that you understand how it works on the inside, it can serve you even better.

LISTING 1 INSIDE MICROSOFT BASIC

```
10 PRINT "FILE NAME?" : LINE INPUT F$
20 OPEN F$+".BAS" FOR INPUT AS #1
30 TEXT$=INPUT$(8,#1)
40 FOR I=1 TO 8 : C=ASC(MID$(TEXT$,I,1))
50 IF C>31 AND C<128 THEN C$=CHR$(C) ELSE C$=" "
60 PRINT USING "### \\ !  ";C;HEX$(C);C$;
70 NEXT I : GOTO 30
80 CLOSE
```

LISTING 2 INSIDE MICROSOFT BASIC

```
10 DEF SEG : DEFINT A-Z
20 OFFSET=PEEK(&H30)+256*PEEK(&H31)
30 FOR I=3500 TO 32767
40 IF 64=PEEK(I) THEN 50 ELSE 90
50 IF 64=PEEK(I+1) THEN 60 ELSE 90
60 IF 64=PEEK(I+2) THEN 70 ELSE 90
70 IF 64=PEEK(I+3) THEN 80 ELSE 90
80 START=I-1 : GOTO 110
90 NEXT I
100 IF I>=32767 THEN 170
110 PREFIX=32 ' OR 253,254,255
120 BASE=128
130 FOR I=0 TO 224 STEP 2
140 POKE START+I,PREFIX
150 POKE START+I+1,BASE+I\2
160 NEXT
170 END
180 PRINT "@@@@
```

LISTING 4 INSIDE MICROSOFT BASIC

```
10 L.=1000 ' change as needed
20 DEF FNT(X$)=3600*VAL(LEFT$(X$,2))+60*VAL(MID$(X$,4))+VAL(RIGHT$(X$,2))
30 T.=FNT(TIME$)
40 FOR I.=1 TO L.
50 ' fill with statement set 1
60 NEXT : PRINT FNT(TIME$)-T.
70 T.=FNT(TIME$)
80 FOR I.=1 TO L.
90 ' fill with statement set 2
100 NEXT : PRINT FNT(TIME$)-T.
```

LISTING 3 INSIDE MICROSOFT BASIC

```
10 DEFINT A-Z : DEF SEG
20 ' the BASIC statement will go into the next line
30 DEF FNF(X)=||'
40 ' setup keyword list
50 DIM K$[10],K[10]
60 FOR I=1 TO 10 : READ K$[I],K[I] : NEXT
70 DATA SGN,132,ABS,134,INT,133,SQR,135,EXP,139,LOG,138
80 DATA SIN,137,COS,140,TAN,141,ATN,142
90 ' get string, loop thru characters
100 INPUT "ENTER YOUR FUNCTION: ";E$ : L=LEN(E$) : X$=""
110 FOR I=1 TO L : C$=MID$(E$,I,1) : A=ASC(C$)
120 IF C$="(" OR C$=")" THEN X$=X$+C$ : GOTO 540 ' copy parentheses
130 ' is it an arithmetic operator?
140 P=INSTR("+-*/^",C$)
150 IF P>0 THEN X$=X$+CHR$(232+P) : GOTO 540
160 IF C$="\" THEN X$=X$+CHR$(244) : GOTO 540
170 ' is it a name?
180 IF A<65 OR A>90 THEN 290 ' letter?
190 N$=C$
200 FOR J=1 TO LEN(E$)-I : C$=MID$(E$,I+J,1) : A=ASC(C$)
210 IF NOT (A>64 AND A<91) OR (A>47 AND A<58) OR C$="." THEN 230 'end of name?
220 N$=N$+C$ : NEXT
230 I=I+J-1
240 ' is it a keyword?
250 FOR J=1 TO 10
260 IF N$=K$[J] THEN X$=X$+CHR$(255)+CHR$(K[J]) : GOTO 540 ' prefix, keyword
270 NEXT
280 X$=X$+N$ : GOTO 540
290 ' is it a number?
300 IF (A>47 AND A<58) OR C$="." THEN 320 ' digit or point?
310 PRINT "INVALID EXPRESSION: "+E$ : STOP
320 ' get the entire number
330 N$=C$
340 FOR J=1 TO LEN(E$)-I : C$=MID$(E$,I+J,1) : A=ASC(C$)
350 IF NOT (A>47 AND A<58) OR C$="." THEN 370 ' end of number?
360 N$=N$+C$ : NEXT
370 I=I+J-1
380 ' is it well-formed?
390 N#=VAL(N$) : IF 0<>N# OR N$="0" THEN 410
400 PRINT "INVALID EXPRESSION: "+E$ : STOP
410 ' convert to proper form
420 IF N#<>INT(N#) THEN 480 ELSE N=VAL(N$) ' integer or decimal number?
430 ' integers
440 IF 1=LEN(N$) THEN X$=X$+CHR$(N+17) : GOTO 540 ' single decimal digit
450 IF N>=0 AND N<256 THEN X$=X$+CHR$(15)+CHR$(N) : GOTO 540 ' single byte
460 IF ABS(N)>32768! THEN 480 ELSE A=VARPTR(N)
470 X$=X$+CHR$(28)+CHR$(PEEK(A))+CHR$(PEEK(A+1)) : GOTO 540 ' two bytes
480 ' floating point
490 N!=VAL(N$)
500 ' single precision if less than 7 digits, double otherwise
510 IF LEN(N$)>8 THEN A=VARPTR(N#) : C=8 ELSE A=VARPTR(N!) : C=4
520 IF C=4 THEN X$=X$+CHR$(29) ELSE X$=X$+CHR$(31) ' floating point prefixes
530 FOR J=0 TO C-1 : X$=X$+CHR$(PEEK(A+J)) : NEXT
540 NEXT I
550 ' find the place to put the expression
560 A=PEEK(&H30)+256*PEEK(&H31) ' start of program text
570 FOR I=A TO 32767
580 IF 124=PEEK(I) AND 124=PEEK(I+1) THEN 600 ELSE NEXT ' find ||
590 STOP
600 FOR J=1 TO LEN(X$) : POKE I+J-1,ASC(MID$(X$,J,1)) : NEXT ' store statement
```

LISTING 5 INSIDE MICROSOFT BASIC

```
10 ' BASIC program cross reference
20 GOSUB 110 ' initialize
30 GOSUB 280 ' ask user
40 GOSUB 360 ' start up
50 GOSUB 420 ' identify tokens
60 GOSUB 1190 ' sort tokens
70 GOSUB 1360 ' print tokens
80 END
90 '
100 ' *** INITIALIZE ***
110 DEFINT A-Z : DEF SEG : OPTION BASE 1
120 A=0:C$="":T$="":C=1:I=0:J=0:K=0:L=0:M=0:X=0:Y=0:Z=0:B=0:D=0:H=0
130 T1$=CHR$(1) : T2$=CHR$(2) : T3$=CHR$(3) : T4$=CHR$(4) : T5$=CHR$(5)
140 DIM S[20,2]
150 DIM CK$[124] : FOR I=1 TO 124 : READ CK$[I] : NEXT
160 DATA END,FOR,NEXT,DATA,INPUT,DIM,READ,LET,GOTO,RUN,IF,RESTORE,GOSUB,RETURN,R
EM,STOP,PRINT,CLEAR,LIST,NEW,ON,WAIT,DEF,POKE,CONT,"?","?",OUT,LPRINT,LLIST,"?",
WIDTH,ELSE
170 DATA TRON,TROFF,SWAP,ERASE,EDIT,ERROR,RESUME,DELETE,AUTO,RENUM,DEFSTR,DEFINT
,DEFSNG,DEFDBL,LINE,WHILE,WEND,CALL,"?","?","?",WRITE,OPTION,RANDOMIZE,OPEN,CLOS
E,LOAD,MERGE,SAVE,COLOR
180 DATA CLS,MOTOR,BSAVE,BLOAD,SOUND,BEEP,PSET,PRESET,SCREEN,KEY,LOCATE,"?",TO,T
HEN,TAB(,STEP,USR,FN,SPC(,NOT,ERL,ERR,STRING$,USING,INSTR,"'",VARPTR,CSRLIN,POIN
T,OFF,INKEY$,"?","?"
190 DATA "?","?","?","?","?",">","=","<","+","-","*","/","^","AND","OR","XOR","E
QV","IMP","MOD","\","?","?","?","?","?","?","?","?"
200 DIM CF$[37] : FOR I=1 TO 37 : READ CF$[I] : NEXT
210 DATA LEFT$,RIGHT$,MID$,SGN,INT,ABS,SQR,RND,SIN,LOG,EXP,COS,TAN,ATN,FRE,INP,P
OS,LEN,STR$,VAL,ASC,CHR$,PEEK,SPACE$,OCT$,HEX$,LPOS,CINT,CSNG,CDBL,FIX,PEN,STICK
```

```
,STRIG,EOF,LOC,LOF
220 DIM DK$[30] : FOR I=1 TO 30 : READ DK$[I] : NEXT
230 DATA FILES,FIELD,SYSTEM,NAME,LSET,RSET,KILL,PUT,GET,RESET,COMMON,CHAIN,DATE$
,TIME$,PAINT,COM,CIRCLE,DRAW,PLAY,TIMER,IOTCTL,MKDIR,SHELL,VIEW,PMAP,ERDEV,CHDIR
,RMDIR,ENVIRON,WINDOW
240 DIM DF$[6] : FOR I=1 TO 6 : READ DF$[I] : NEXT
250 DATA CVI,CVS,CVD,MKI$,MKS$,MKD$
260 RETURN
270 '
280 ' *** ASK USER ***
290 INPUT "FILE NAME";X$ : OPEN X$ FOR INPUT AS #1 : M=LOF(1)
300 DIM S$[M\2],P[M\2] ' adjust if low on memory
310 PRINT "EACH OF THESE CAN BE LISTED:" : PRINT "KEYWORDS, VARIABLES, LINE NUMB
ERS, NUMBERS, STRINGS": INPUT "LIST (K,V,L,N,S)";Y$
320 Z$="KVLNS"
330 FOR I=1 TO LEN(Y$) : O[INSTR(Z$,MID$(Y$,I,1))]=-1 : NEXT
340 RETURN
350 '
360 ' *** START UP ***
370 PRINT "ANALYZING"
380 FOR I=1 TO 3:GOSUB 1520:NEXT
390 GOSUB 1520 : B=A : GOSUB 1520 : L=B+256*A
400 PRINT STR$(L); : RETURN
410 '
420 ' *** IDENTIFY TOKENS ***
430 GOSUB 1520:IF EF THEN 1170
440 IF A<128 THEN 630
450 ' *** KEYWORDS ***
460 IF A=143 THEN 550 ' REMARK?
470 IF A=132 THEN 590 ' DATA?
480 IF A<253 THEN X=252 ELSE X=A:GOSUB 1520
490 ON X-251 GOTO 500,510,520,530
500 T$=CK$[A-128]:GOTO 540 ' Cassette keyword
510 T$=DF$[A-128]:GOTO 540 ' Disk function
520 T$=DK$[A-128]:GOTO 540 ' Disk keyword
530 T$=CF$[A-128]:GOTO 540 ' Cassette function
540 T$=T1$+T$:GOTO 1140
550 ' *** REMARK ***
560 T$="":GOSUB 1520:IF A<>217 THEN T$=T$+C$
570 GOSUB 1520:IF 0=A THEN GOSUB 1640 ELSE T$=T$+C$:GOTO 570
580 GOTO 1160
590 ' *** DATA ***
600 T$=""
610 GOSUB 1520:IF 0=A THEN GOSUB 1640 ELSE T$=T$+C$:GOTO 610
620 GOTO 1160
630 IF A<65 OR A>90 THEN 680
640 ' *** NAME ***
650 T$=C$
660 GOSUB 1520:IF(A>64 AND A<91)OR(A>47 AND A<58)OR A=46 OR A=33 OR A=35 OR A=36
 OR A=37 THEN T$=T$+C$:GOTO 660 ELSE GOSUB 1640
670 T$=T2$+T$:GOTO 1140
680 IF A<>14 THEN 720
690 ' *** LINE NUMBER ***
700 GOSUB 1520:B=A:GOSUB 1520:T$=STR$(B+256*A)
710 T$=T3$+T$:GOTO 1140
720 IF A<>34 THEN 770
730 ' *** LITERAL CONSTANT ***
740 T$=C$
750 GOSUB 1520:T$=T$+C$:IF A=34 THEN 760 ELSE 750
760 T$=T5$+T$:GOTO 1140
770 IF A<17 OR A>26 THEN 810
780 ' *** 1 DECIMAL DIGIT CONSTANT ***
790 T$=STR$(A-17)
800 T$=T4$+T$:GOTO 1140
810 IF A<>15 THEN 850
820 ' *** 1 BYTE INTEGER CONSTANT ***
830 GOSUB 1520:T$=STR$(A)
840 T$=T4$+T$:GOTO 1140
850 IF A<>28 THEN 890
860 ' *** 2 BYTE SIGNED INTEGER ***
870 GOSUB 1520:B=A:GOSUB 1520:T$=STR$(B+256*A)+"%"
880 T$=T4$+T$:GOTO 1140
890 IF A<>29 THEN 940
900 ' *** 4 BYTE FLOATING POINT ***
910 T$="":X=VARPTR(N!)
920 FOR I=0 TO 3:GOSUB 1520:POKE X+I,A:NEXT:T$=STR$(N!)+"!"
930 T$=T4$+T$:GOTO 1140
940 IF A<>31 THEN 990
950 ' ***** 8 BYTE FLOATING POINT *****
960 T$="":X=VARPTR(N#)
970 FOR I=0 TO 7:GOSUB 1520:POKE X+I,A:NEXT:T$=STR$(N#)+"#"
980 T$=T4$+T$:GOTO 1140
990 IF A<>11 AND A<>12 THEN 1030
1000 ' *** 2 BYTE HEX/OCTAL INTEGER ***
1010 GOSUB 1520:B=A:GOSUB 1520:T$=STR$(B+A*256)+"&"
1020 T$=T4$+T$:GOTO 1140
1030 IF A=32 OR A=35 OR A=40 OR A=41 OR A=44 OR A=45 OR A=58 OR A=59 OR A=91 OR
A=93 THEN 1160
1040 IF A<>0 THEN 1090
1050 ' *** END OF LINE ***
1060 GOSUB 1520 : GOSUB 1520 : GOSUB 1520 : B=A : GOSUB 1520 : L=B+256*A
1070 IF L<>0 THEN PRINT STR$(L); : GOTO 1160 ELSE 1170
1080 ' *** OTHER ***
1090 IF A>47 AND A<58 THEN STOP ' ASCII digits are impossible
1100 IF A>96 AND A<122 THEN STOP ' lower case letters are impossible
1110 IF A<11 OR A=13 OR A=15 OR A=16 OR A=30 THEN STOP ' impossible
1120 STOP ' A wasn't an ASCII value
1130 ' *** STORE TOKEN ***
1140 IF NOT O[ASC(LEFT$(T$,1))] THEN 1160
1150 K=K+1:S$[K]=T$:P[K]=L
1160 GOTO 430
1170 RETURN
1180 '
1190 ' *** SORT TOKENS ***
1200 PRINT:PRINT "SORTING"
1210 D=1:S[D,1]=1:S[D,2]=K
1220 WHILE D>0:L=S[D,1]:H=S[D,2]:D=D-1
1230 IF L>=H THEN 1340
1240 I=L:J=H:X=H
1250 WHILE(I<J)AND(S$[I]<=S$[X]):I=I+1:WEND
1260 WHILE(J>I)AND(S$[J]>=S$[X]):J=J-1:WEND
1270 IF I<J THEN SWAP S$[I],S$[J]:SWAP P[I],P[J]:GOTO 1250
1280 IF I<>H THEN SWAP S$[I],S$[H]:SWAP P[I],P[H]
1290 IF(I-L)>=(H-I)THEN  1320
1300 D=D+1:S[D,1]=L:S[D,2]=I-1
1310 D=D+1:S[D,1]=I+1:S[D,2]=H:GOTO 1340
1320 D=D+1:S[D,1]=I+1:S[D,2]=H
1330 D=D+1:S[D,1]=L:S[D,2]=I-1:GOTO 1340
1340 WEND : RETURN
1350 '
1360 ' *** PRINT LISTING ***
1370 C=0:FOR I=1 TO K:IF LEN(S$[I])>C THEN C=LEN(S$[I])
1380 NEXT
1390 CR$=CHR$(13) : M=K : K=0 : P$=CR$ : DIM L[100]
1400 FOR I=1 TO M:T$=MID$(S$[I],2)
1410 IF P$=T$ THEN K=K+1:L[K]=P[I]:GOTO 1480
1420 IF P$=CR$ THEN K=1:P$=T$:L[K]=P[I]:GOTO 1480
1430 IF K=1 THEN 1460
1440 FOR X=1 TO K:FOR Y=X TO K:IF L[X]>L[Y] THEN SWAP L[X],L[Y]
1450 NEXT:NEXT
1460 LPRINT:LPRINT LEFT$(P$+SPACE$(C),C);:FOR J=1 TO K:LPRINT L[J];:NEXT
1470 K=1:P$=T$:L[K]=P[I]
1480 NEXT
1490 LPRINT:LPRINT LEFT$(P$+SPACE$(C),C);:FOR J=1 TO K:LPRINT L[J];:NEXT:LPRINT
1500 RETURN
1510 '
1520 ' *** GET CHAR, ADVANCE CURSOR ***
1530 IF LB AND C=LEN(B$) THEN EF=-1:RETURN
1540 IF C<=LEN(B$) THEN 1610 ' chars in buffer?
1550 P$=B$ ' save previous buffer
1560 IF M>J+128 THEN 1590 ' more full blocks left?
1570 C=1:B$="" ' accumulate last partial block
1580 WHILE NOT EOF(1):B$=B$+INPUT$(1,#1):WEND:LB=-1:GOTO 1610
1590 P$=B$:B$=INPUT$(128,#1)
1600 C=1:J=J+128
1610 C$=MID$(B$,C,1):A=ASC(C$):C=C+1:RETURN
1620 '
1630 ' *** RETRACT CURSOR ***
1640 IF C=1 THEN B$=P$:C=255 ELSE C=C-1
1650 RETURN
```

SQL on the IBM PC

A system that follows faithfully the SQL relational standard in both syntax and functionality.

Clyde W. Holsapple

Structured Query Language/Data System (SQL/DS), an IBM data base management tool, is the present-day standard for relational systems. It allows data to be organized into tables and then processed by means of high-level commands furnished in a structured query language. Since 1982, SQL/DS has been available on mainframes; now there's a microversion of the system for the IBM personal computer, called Knowledge Manager (Knowledge Man). This system faithfully follows the SQL relational standard in both syntax and functionality.

The descriptions that follow illustrate highlights of SQL on the IBM Personal Computer. Variations between mainframe SQL/DS and the micro SQL embodied in KnowledgeMan are noted. Variations that do exist between KnowledgeMan's structured query language and SQL/DS are primarily the result of KnowledgeMan features that are unavailable in SQL/DS. Readers familiar with one or more of the commonplace micro file handlers (such as dBase) will readily observe that the SQL data handling commands are quite different and considerably more powerful than those of file handlers.

Data Organization

Data is organized into tables such as those shown in figure 1. Each column represents a field. For instance, the SUPPLIER table has six fields which are useful in characterizing suppliers. Each row in a table is a record, consisting of a data value for each of the table's fields. The SUPPLIER table shows five records, each one describing a particular supplier.

As figure 1 illustrates, relationships between rows in one table and rows in another table are established by means of a field repeated in both tables. For instance, the fact that a suppplier identification field exists in both the SUPPLIER and QUOTE tables implies that particular supplier records are related to particular quotation records. Suppose we want to find the names of suppliers who supply part number 342. From the QUOTE table, all supplier identifiers (SID) for part 342 can be found. These are compared to supplier identifiers in the SUPPLIER table. Whenever a match occurs, the corresponding supplier name (SNAME) is extracted from the SUPPLIER record for display. This entire lookup and display process for two tables is accomplished by a single SQL command.

SQL Queries

An SQL query is a non-procedural command that causes data to be retrieved from one or more tables. Non-procedurality means that the user who states a query does not need to explicitly specify a sequence of steps (i.e., a procedure) that tells the system *how* to perform the retrieval. Instead, the user states a single command that tells the system *what* data is desired. The system responds to such a query by presenting the retrieved data values in the form of a table, which is referred to as the query's output table.

The basic structure of an SQL query consists of three clauses: a SELECT command, followed by the desired fields; a FROM command, followed by the table that is the source of information; and a WHERE command, followed by the conditions to be met. The query is typed as SELECT . . . FROM . . .

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SUPPLIER

SID	SNAME	STREET	CITY	STATE	ZIP
13	PERFECTO PARTS	100 MAIN ST.	CARROLL	IOWA	51401
25	XYZ SUPPLY	35 RUDOLPH	CHICAGO	ILLINOIS	60005
18	PACIFIC CO.	BOX 2048	NEW YORK	NEW YORK	10017
49	FITZ HARDWARE	25 SAGE DR.	PITTSBURGH	PENNSYLVANIA	15432
103	MISCELL PARTS	135 WICKER DR.	CHICAGO	ILLINOIS	60003

PART

PID	PNAME	DESCRIP	ONHAND
195	*WHEEL*	*8 INCH, ALUM*	*35*
203	*BOLT*	*½ DIA, 2 LEN*	*500*
214	*BELT*	*22 INCH*	*230*
342	*WASHER*	*¾ INCH*	*5200*
343	*BOLT*	*¾ DIA, 4 LEN*	*6000*

QUOTE

SID	*PID*	*PRICE*	*TIME*	*ONORD*
13	*195*	*1.35*	*6*	*50*
13	*214*	*.85*	*2*	*200*
13	*395*	*12.14*	*12*	*0*
25	*342*	*.03*	*5*	*7000*
25	*343*	*.05*	*6*	*15000*
49	*342*	*.02*	*7*	*12000*
49	*343*	*.06*	*7*	*0*
49	*386*	*3.25*	*20*	*100*

Figure 1: Sample tables generated by SQL

> *A user does not need to devise and execute a series of commands that involve merging files together to produce various intermeiate files. The relation SQL approach saves effort (by reducing both file handling and the chance of errors) and storage space.*

WHERE . . . . The user specifies the fields for which data values are to be retrieved, the table(s) from which the retrieval is to occur, and certain conditions which are to be satisfied by retrieved data. The output table has one column for each selected field and these columns appear left to right in the same order in which fields are stated in the query. If the optional WHERE clause is used in a query, then the data of each row in the output table satisfies whatever conditions are specified in that clause. As discussed later, an SQL query can have other clauses.

Referring to figure 1, suppose we want to obtain a report showing the identifier, name, description, and quantity-on-hand for each part, then the query is

```
SELECT PID, PNAME, DESCRIP,
  ONHAND FROM PART
```

The result of this unconditional retrieval is an output table that is identical to the PART table. More selective retrieval is accomplished with the WHERE clause. For instance,

```
SELECT PID, PNAME, ONHAND
  FROM PART WHERE ONHAND)750
```

produces a three column output table showing the identifier, name, and quantity of every part whose quantity-on-hand exceeds 750.

In addition to fields, expressions involving fields can be stated in a query. The output table contains a column for each such expression. The query

> *KnowledgeMan SQL permits extensive flexibility in specifying conditions. Any of the usual relational operators can be employed in stating a condition.*

```
SELECT PID, SID,ONORD*PRICE
  FROM QUOTE WHERE ONORD)O
```

generates a three-column output table whose last column shows the total dollar amount on order for each part from each supplier (providing an order has been placed). Expressions in the KnowledgeMan version of SQL can be arbitrarily complex, involving any of the more than 25 built-in functions (e.g., square root, logs, random numbers, trig functions, etc.) temporary working variables, spreadsheet cell variables, and fields from multiple tables.

Each field or expression selected can be qualified by a picture, that shows how its values are to be edited as they are displayed in the output table. For example,

```
SELECT SID,TIME/7 USING "ddd.dd
  WEEKS" FROM QUOTE WHERE
  PID=342
```

produces an output table showing the suppliers who can supply part 342. For each supplier, the delivery time (in weeks) is computed and is displayed with two decimal digits, followed by the word WEEKS. This KnowledgeMan editing capability is not supported in traditional SQL.

KnowledgeMan SQL permits extensive flexibility in specifying conditions. Any of the usual relational operators (⟨, ⟩, =, ‡, ⟨, ⟩,) can be employed in stating a condition. Fields and complex expressions can be used as operands. For instance,

```
SELECT SID, PID FROM QUOTE
  WHERE ONORD/(TIME+2))15/SQL
  RT(PRICE)
```

illustrates a condition involving three fields and the built-in square root (SQRT) function. A group inclusion operator (IN) is also supported. Thus,

```
SELECT SNAME,SID FROM
  SUPPLIER WHERE STATE IN
  ["Iowa","Illinois","Ohio"]
```

produces a report of those suppliers in Iowa, Illinois, or Ohio.

A condition can also involve

wild card string and wild card symbol matches. In the following query, * is used as a wild card string match character to obtain an output table showing all aluminum parts.

```
SELECT PID,PNAME FROM PART
  WHERE DESCRIP IN ["*ALUM*"]
```

Whereas the * matches any string of symbols, the $ character is used to indicate a wild card match with exactly one symbol. Therefore,

```
SELECT PID, PNAME,DESCRIP
  FROM PART WHERE PNAME
  IN ["B$LT"]
```

extracts those parts whose names consist of four symbols, the first of which is B and the last of which are LT (e.g., BOLT, BELT).

Arbitrarily complex compound conditions can be specified with the AND (&), OR, XOR (exclusive OR), and NOT logical operators. To obtain a list of all suppliers who can supply part 529 at a unit price of less than .23 in less than seven days, the query is

```
SELECT SID FROM QUOTE WHERE
  PID=529 & PRICE<.23 & TIME<7
```

For the same part, we may be willing to sacrifice time for price or vice versa. Thus,

```
SELECT SID,PRICE,TIME FROM
  QUOTE WHERE PID=529 &
  PRICE<.17 OR TIME<5)
```

will show suppliers who can deliver part 529 in less than five days (possibly at a high price) or who can deliver for a unit price below.

Though it is not a part of traditional SQL, KnowledgeMan also allows the query to be restricted to a particular portion of a table.

```
SELECT PID,DESCRIP FROM PART
  WHERE ONHAND>5000 RANGE 200,300
```

processes only records 200 through 300 in producing the output table.

PID	*SID*	*TIME*
⋮	⋮	⋮
195	*13*	*6*
195	*52*	*7*
203	*73*	*5*
203	*52*	*5*
203	*103*	*6*
203	*129*	*6*
214	*13*	*2*
214	*103*	*2*
⋮	⋮	⋮

a) SELECT PID,SID,TIME FROM QUOTE ORDER BY ASCENDING PID,TIME

PID	SID	TIME
⋮	⋮	⋮
195	13	6
	52	7
203	73	5
	52	
	103	6
	129	
214	13	2
	103	
⋮	⋮	⋮

b) SELECT UNIQUE PID, SID, UNIQUE TIME FROM QUOTE ORDER BY ASCENDING PID, TIME

Figure 2: SQL's UNIQUE Qualifier

Records outside of this range, for which the quantity on hand exceeds 5000, are ignored. There are several ways aside from RANGE for specifying what portion of a table is of interest.

Each of the foregoing examples has operated on only one table at a time. In addition, a KnowledgeMan SQL query, using any mix of the previously described features, can operate on multiple tables to produce an output report. Unlike micro file management systems, a user does not need to devise and execute a series of commands that involve merging files together to produce various intermediate files. The relational SQL approach saves user effort (by reducing both file handling and the chance of user errors) and storage space.

Suppose a report is needed showing part name, number and quantity on hand, plus the quantities of each part that are on order from various suppliers. Notice that this information does not exist in a single table. It involves fields in the QUOTE and PART tables. For clarity, each field name in the following query is prefaced by the table in which it exists (e.g., the field PID exists in two tables). Actually, all of these prefaces are not required.

```
SELECT PART.PNAME,PART.PID,
  PART.ONHAND,QUOTE SID,
  QUOTE.ONORD FROM QUOTE
  WHERE QUOTE.ONORD>0 FROM
  PART WHERE PART.PID = QUOTE.PID
```

For each QUOTE record with an ONORD>0, the system extracts related part data from the PART table record having the same PID value as the QUOTE record. The result is the desired five-column output table consisting of related data from the PART and QUOTE tables.

More than two tables can be referenced in a single query. To produce an output table showing the name of the supplier, the part description, and the quantity on order for each aluminum part having a price over 10.50:

```
SELECT SUPPLIER.SNAME, PART.
  DESCRIP,ONORD FROM QUOTE
  WHERE PRICE>10.50 FROM PART
  WHERE PART.PID=QUOTE.PID&
  PART.DESCRIP IN ["*ALUM*"]
  FROM SUPPLIER WHERE
  SUPPLIER.SID=QUOTE.SID
```

This KnowledgeMan treatment of multiple tables varies slightly from that of SQL/DS. In SQL/DS the multiple tables are specified in the same FROM clause and the multiple conditions are put into the same WHERE clause, creating a query with a less structured appearance.

As with SQL, a KnowledgeMan user can append an ORDER clause to any query to cause the output table to be dynamically sorted on any desired criteria. Rows in the output

table produced by

SELECT SNAME,CITY,STATE,ZIP FROM SUPPLIER ORDER BY ASCENDING ZIP,CITY,SNAME

are sorted on an ascending basis by zip code, by city within zip code, and by supplier name within city. A mixture of ascending and descending orders can be specified in the KnowledgeMan version of SQL. Thus

SELECT SID,PID,ONORD, TIME, PRICE FROM QUOTE ORDER BY DESCENDING ONORD, ASCENDING TIME, DESCENDING PRICE

orders the output rows by descending order amount, by ascending time within an order amount, and by descending price within each time.

In SQL, a table is initially defined by name and then by a list of the names, types, and sizes of fields involved in that table. The syntax for table definition differs somewhat in the KnowledgeMan version of SQL.

Another valuable feature is the UNIQUE qualifier, which causes consecutive duplicate values in an output table's column to be suppressed. The word UNIQUE can be used to qualify any selected field or expression. The query

SELECT UNIQUE PID,SID, UNIQUE TIME FROM QUOTE ORDER BY ASCENDING PID,TIME

generates a normal output table except that once a particular part number appears in an output row, the display of that number will be suppressed in subsequent output rows. The same is true for the output table's TIME column. Figure 2b shows a fragment of this ouput table.

A final optional clause that can be used with the SQL SELECT command is the GROUP BY clause. This is used to cause statistics to be calculated and displayed for indicated groups of data. In conventional SQL, the user must explicitly state within the query itself which statistics (e.g., average, min, max) are to be computed for which fields. In the KnowledgeMan version of SQL this is not necessary, since its GROUP BY clause causes control breaks with full statistics to be generated at each control break. For instance, the KnowledgeMan query

SELECT PID,PRICE,TIME FROM QUOTE GROUP BY PID ORDER BY ASCENDING PID

causes part number, price, and time to appear in sorted order in the output table. Whenever the value of PID changes from one row to the next in this table, there is a break in the table. At each break, full statistics (average, min, max, standard deviation, etc.) are computed and displayed for price and time, using the price and time data displayed since the last break. Thus for each part, full statistics are shown for its price and time. At the end of the output table, global statistics are also displayed.

An added advantage of the KnowldedgeMan variation of SQL's GROUP BY clause is that it allows statistics to be generated at multilevel control breaks. So,

SELECT PID,TIME,PRICE FROM QUOTE GROUP BY PID,TIME ORDER BY ASCENDING PID,TIME

produces control break statistics whenever the value of PID changes in the ouput table. At a more detailed level, the GROUP BY clause also generates control break statistics for each group of items within each part group. For instance, price statistics are displayed for those suppliers who can supply part 343 in 6 days. At a higher level, there are statistics for part 343, regardless of delivery time. Any of the statistics can be selectively suppressed, if desired.

The SELECT command is a powerful and flexible way of generating a desired output table from one or more existing tables of data. KnowledgeMan has another command ,CONVERT, similar to SELECT, except that the output table is not displayed, printed, or routed to a disk file as it is with SELECT. Instead, the output table is converted to a desired format (e.g., BASIC-compatible, DIF, ASCII) and written to a disk file. This data file can then be used by external programs (e.g., graphics utilities) that can read files formatted in these ways.

Table Definition and Modification in SQL

In SQL, a table is initially defined by name and then by a list of the names, types, and sizes of fields involved in that table. The syntax for table definition differs somewhat in the KnowledgeMan version of SQL: In KnowledgeMan a table can be defined interactively, virtual fields can be defined, various access protection codes can be specified for the table and its fields, and pictures can be assigned to fields.

A virtual field is one that is defined in terms of other fields in the table and whose "values" do not actually consume any space in the table. Nevertheless, a virtual field can be treated just like an actual field within any SQL command. For the supplier table, the virtual field ADDRESS can be defined by entering

ADDRESS = STREET + CITY + STATE + ZIP STR 35

in response to the interactive prompt to define a new field. Whenever ADDRESS is used in a query, its values consist of a 35–character string formed from the concatena-

tion of street, city, state, and zip code data. Numeric virtual fields can also be defined. For example,

PTRATIO = PRICE/TIME NUM

defines a virtual field in QUOTE, whose values are the ratio of price to time. Arbitrarily complex expressions (including built-in functions) can be used when defining a virtual field. In traditional SQL, virtual fields are not defined when the table is defined. They can be specified later with a separate command.

For data security, access protection codes can be specified as a KnowledgeMan table is defined. These can be specified for the table as a whole or individually for selected fields. The access codes for one field can be different than those of another field. Only those users who have access privilege codes in common with a field's access protection codes will be able to access that field's values. A further security distinction is made between read access and write access (i.e., the ability to see data versus the ability to change it). Conventional SQL also offers comparable field-level data security, but it is not specified when a table is defined. It is accomplished later by separate command.

For automatic editing and intergrity checking, a picture can be assigned to a field when the field is defined. Conventional SQL does not make use of pictures. Like SQL/DS, KnowledgeMan allows a table to be redefined at any time. This may involve adding or deleting fields, changing field types and sizes, changing access codes, changing pictures, and so forth.

Any time after definition, records can be created in the table. The micro SQL command differs from the mainframe SQL/DS command for record creation by supporting fully interactive record creation. When a user indicates a desire to insert a new record (or records) at a desired place in the table, the user is prompted to provide values for each field. As an alternative to the standard prompting format, the user can ask to create the record via a customized input form:

CREATE RECORDS FOR SUPPLIER WITH SUPFORM

Here, SUPFORM is the name of a customized data entry form previously declared by the user. In declaring a form, there is complete control over the positionings of form elements such as titles, labels, and data entry slots. The form declaration can also specify various special effects for any form element, including foreground/background colors, blinking, intensity, bells, and reverse video.

Just as customized forms can be used for record creation, they can also be used for browsing through a table's records. That is, the values of each successive record appear in a customized form and the user can modify any of the values, as needed. Of course, this modification is subject to write access privileges and protections. KnowledgeMan also supports the SQL/DS approach to modifying records. For instance, the command

CHANGE ONHAND TO ONHAND + 720 WHERE PID = 472

adds 720 to the present quantity on hand for part number 472. Multiple records can also be changed with this command. Suppose that supplier 103 has announced an immediate eight percent price increase on all of its parts with the exception of parts 472 and 345, then

CHANGE PRICE TO PRICE*1.08 WHERE SID = 103&PID NOT IN [472,345]

is a single command that accomplishes all of these changes.

Unlike SQL/DS, all data processed with the KnowledgeMan version of SQL is automatically stored in encrypted form. This added security feature is particularly important in the micro environment, because it protects data from disclosure through the casual use of operating system commands.

INVENTORY

SID	PID	PARTNAME	PARTDES	ONHAND	PRICE	TIME	ONORD
13	195	WHEEL	8 INCH, ALUM	35	1.35	6	50
13	214	BELT	22 INCH	230	.85	2	200
13	395	WIDGET	5 x 5 ABRIGEN	12	12.14	12	0
25	342	WASHER	¾ INCH	5200	.03	5	7000
25	343	BOLT	¾ DIA, 4 LEN	6000	.05	6	15000
49	342	WASHER	¾ INCH	5200	.02	7	12,000
49	343	BOLT	¾ DIA, 4 LEN	6000	.06	7	0
49	386	BELT	48 INCH	725	3.25	20	100

Figure 3: An SQL Virtual INVENTORY table

Virtual Tables for SQL

Virtual tables can be defined with SQL. A virtual table has fields, just like the actual tables previously discussed. Physically speaking, the data values of a virtual table do not exist as an actual table in storage. However, a user can view a virtual table as if it were an actual table. A major advantage of a virtual table is that it allows a user to believe that he or she is working with a single table, while data is actually being retrieved from multiple tables. The following example illustrates how to define a virtual table in the KnowledgeMan version of SQL.

Suppose a user wants to frequently extract data from the INVENTORY table shown in figure 3, rather than the PART and QUOTE tables in figure 1. Instead of generating a space-consuming actual INVENTORY table from the QUOTE

and PART tables, he can define a virtual INVENTORY table with a command called MACRO. Since KnowledgeMan allows commands to be renamed, the following example assumes that MACRO has been given a more descriptive name: VIEW.

Notice that the PNAME field in PART is to be viewed as PARTNAME in the INVENTORY table. This is accomplished by declaring

```
VIEW PARTNAME PART.PNAME
```

The PARTDES and QONHAND views for PART.DESCRIP and PART.ONHAND are declared similarly. Synonyms for other field names could also be created in this way. To declare the virtual INVENTORY table, the command

```
VIEW INVENTORY QUOTE FROM
  PART WHERE PART.PID = QUOTE.PID
```

is used. Now, to retrieve data from INVENTORY, the SQL SELECT command is invoked just as if an actual table were being queried. There is one exception to this in the KnowledgeMan version of SQL: for conditional retrieval the word WHERE is replaced by the word WHEN (synonomous with the & operator). Thus, the query

```
SELECT PID,UNIQUE PARTNAME,
  PARTDES,SID,PRICE FROM
  INVENTORY WHEN TIME < 10 &
  QONHAND <2000 ORDER BY
  ASCENDING PARTNAME,PID
```

generates a five-column output table of part and supplier information for each part whose quantity on hand is below 2000 and which can be supplied by at least one supplier in under ten days. The output table is in sorted order by part name and part identifier, with the display of duplicate names suppressed.

Using SQL within Programs

An important aspect of a relational system is that its commands can be invoked from within programs. Indeed, this is a vital aspect of any type of full-fledged data base management system, for reasons of flexibility and efficiency. SQL/DS commands can be invoked from within programs written in COBOL, PL/1, or assembler. KnowledgeMan SQL commands can also be invoked from within a programming language. This language is an integral part of the KnowledgeMan system. Its features are fairly extensive, supporting array processing and control structures such as if-then-else branching, conditional iteration, switch-case protocols, and parameterized procedure invocation. There are no limits on nesting or the number of variables that can be used.

An important aspect of a relational system is that its commands can be invoked from within programs. Indeed, this is a vital aspect of any type of full-fledged data base management system.

Integrating SQL with Spreadsheet Processing

In addition to an integral structured programming language, KnowledgeMan has a built-in spreadsheet system. A spreadsheet's cells can be used in expressions and conditions of KnowledgeMan SQL commands. Conversely, a spreadsheet cell can be defined in terms of a retrieval statement (or an entire program containing retrieval statements). The full implications of this integration are too lengthy to examine here. It is sufficient to point out that this is a very different approach to integration than that in packages like 1-2-3 and MBA, which use spreadsheets to emulate certain rudimentary data management operations.

Summary

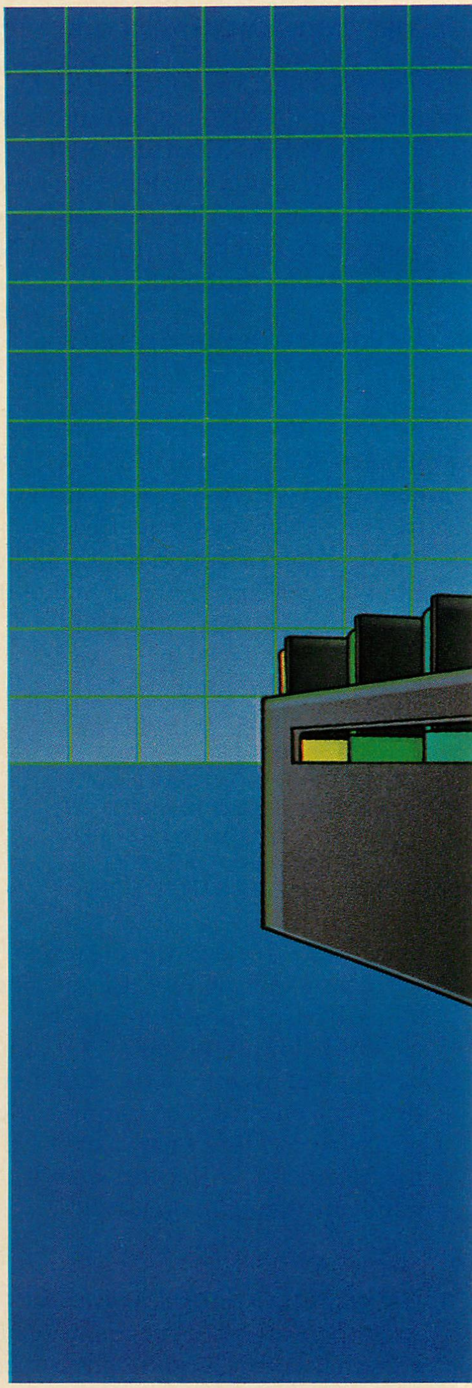
The capabilities of IBM's mainframe relational system, SQL/DS, are now available on the IBM Personal Computer (and other 8086/8088 machines under PCDOS, MSDOS and CP/M-86). Though the KnowledgeMan structured query language closely resembles the mainframe SQL, it does differ in some respects. It does not presently furnish a few of the most complicated SQL/DS capabilities, such as the direct nesting of queries within queries. On the other hand, it supports some features unavailable with conventional SQL. In any event, KnowledgeMan SQL does give micro users a very large measure of the standard relational capabilities that exist on mainframes.

Because KnowledgeMan is restricted to relational data handling, it is not as powerful as post-relational data base management systems. For instance, the post-relational MDBS III is not limited to a tabular data organization, but is able to model much more closely the semantics of real world relationships. One result of this is a query facility that is more concise than SQL's query facility.

For applications where the power of an MDBS III is needed, KnowledgeMan can still be usefully employed for localized decision support activities. Masses of data can be centrally managed on an IBM PC using MDBS. Desired subsets of that data (in tabular form) can be generated with high level, non-procedural MDBS queries. These tables can then be distributed to KnowledgeMan users, who can attach them to KnowledgeMan tables for their own localized use in supporting decisions. The attach activity is accomplished with a single KnowledgeMan command. Thus, the SQL capabilities of KnowledgeMan can be used on a stand-alone basis or at distributed local work stations that draw upon a large centrally managed data base.

THE CALIFO

Ten utilities for the advanced programmer, browser, or confirmed disassembler.



Susan Glinert-Cole

Utilities are the kitchen knives of the computer programmer. With a set of fine, well-tempered utilities, it is possible to daintily explore the structure of a file, eventually serving forth a customized routine or beautifully arranged directory. The more powerful the utility, the easier it is to indulge in unrestrained hashing and mincing. This behavior occasionally culminates in a delicate souffle; often the end result is yesterday's leftover Tuna Fish Surprise.

The California 10-Pak falls into the first category, despite the rather beery implications of the title. This set of utilities consists of ten routines that will view memory and files, sort directories and disassemble object code files. Unlike DEBUG and some of the Norton Utilities like SecMod, they do not allow any permanent changes; the user is compelled to retain a thoughtful, leisurely attitude towards file modifications.

Often the end result of this behavior is yesterday's leftover Tuna Fish Surprise.

Cal-10 is not copy protected and will work with either DOS 1.1. or DOS 2.0. In all cases but one, it managed path names with no problem. All the programs in this set are very fast. Paging from top to bottom of a 200,000–byte file was performed instantly. Directory sorts are finished before the operator can remove the finger that pressed the appropriate key. Cal-10 has excellent error trapping; nothing caused it to crash or lock up the system.

The human interface is also superior. The command set is consistent for all programs. The escape key is used to exit, and PgUp and PgDn flip through the display and operate in the repeat mode when held down. There is no catch-up when these keys are released; response is instant. The display may be sent to the printer with a Shift + PrtSc command; DOS 2.0 redirection is also enabled.

Cal-10's documentation is not particularly elegant, consisting as it does of 15 half-sized pages punched for insertion in a small binder. Instructions for using the programs are very clear and, for the most part, do a good job of explaining the capabilities of each utility. Output from the more esoteric utilities, like

RNIA 10-PAK

CENV, is not explained in the documentation and the onus is on the user to make sense of it. The authors presuppose that only an expert would benefit from some of these programs, but with a reference to the proper sections of the DOS manuals and a short explanatory section in the documentation, intermediate users could use this package as an educational tool.

TEXT FILE UTILITIES

Two programs in this package are designed to inspect the contents of text files: BROWSE and CDIFF. In this respect, BROWSE is identical to the DOS command TYPE, while

> *The third page of CENV lists IBM PC interrupts one through twenty-seven, alongside their respective segments and offsets.*

CDIFF has no counterpart in the operating system. CDIFF will compare two text files, and report synchronous differences found every 100 lines, up to ten differences. For two entirely different files, for example, CDIFF will report that the first difference was found at line one, the second at line 101 and so on. All comparisons are done before the result is displayed, so there is a fair amount of disk activity for a minute or so. The files being compared can be of any length, but the differences can only occupy a maximum of 32K bytes. This program is useful for spotting minor changes in assembly listings and text files. It is of limited value for reporting large differences between files.

All characters are displayed with CDIFF, regardless of whether or not they are normally considered "unprintable." Tabs for example, are represented as little circles. The display is very messy. In fact, if there are large differences between the two files, it is practically unreadable. CDIFF cannot open a file specified by a path; the file must reside in the default directory. It was the only utility in the set that could not use paths.

CODE FILE UTILITIES

CFILE is the "unreadable" file equivalent of BROWSE, but is far more versatile than the latter. It can view either text or binary files. BROWSE displays a file in line format but the output for CFILE is quite different. This utility displays the file one-half a sector at a time. The sector being inspected is shown above the data, with the offset in the left column, the hexadecimal values in the center and the ASCII equivalents on the right hand side of the screen. Because all text delimiters are shown in hexadeci-

Figure 1: Output from CDISK

Output page 1

```
DOS VERSION 2.0

Drive = 1 Media :  Unassigned

Sector 0 Table Missing (Defaults used)

Root Dir. size    = 64
Total Sectors     = 320

Number of Heads   = 1
Sectors per Track= 8
Secs per Cluster = 1
Bytes per Sector = 512

Sectors Reserved = 1
Sectors Hidden    = 0
Number of FATS    = 2
Sectors per FAT   = 1
```

Output page 2

```
No. Clusters on Device = 313
Highest Cluster used   = 291
Total Clusters used    = 290
Unique Cluster Chains  = 5

  Chain=[A-Z]: X..-x    fragment=[x]
  Xlink=[!],  Reserved=[%],  Bad=[?]
  Empty=[-],  Unassigned 0,1    =[¯]

--A....................................
..............B........................
...........................C...........
.......................................
..D....................................
........................E..............
.......................................
............-----------------------
```

Figure 2 : Output from CENV

```
IBM PC Configuration DOS 2.0

No. of Diskettes   = 1

No. of Hard Disks = 1

No. Printers       = 1

No. RS232 Ports    = 2

Game IO Installed = 0

Video Cards: Monochrome Color/Graphic
-Power Up Mode: 80x25 BW   Monochrome
-Current  Mode: 80x25 BW   Monochrome

Planar Memory in KBytes = 64

Total  Memory in KBytes = 320
```

Figure 2a: Output from CENV, page 1

```
PC Diskette Parameter Table Values

Located at segment:offset 0000:0522


Transfer Mode is DMA
Bytes/Sector  = 512
Sectors/Track = 9


Step  Rate  Time in Ms = 28
Head Unload Time in Ms = 480
Head  Load  Time in Ms = 8
Head Settle Time in Ms = 0


Start_Time in secs =    .25
Motor Wait in secs =   2.03

Gap  Length = 42
Data Length = 255
Format Gap  = 80
Format Char = F6
```

mal, this program is very useful for finding out what unprintable characters are placed in a text file by word processors. CFILE is less useful than, say, DEBUT or Norton's SECMOD, because no changes may be made to the data.

CCOMP is similar to CDIFF, but the display is tidier and the information more readable. CCOMP compares two files and displays the differences in both hexadecimal and ASCII. The files themselves need not be of the same size. Each file page is shown in a separate window on the screen and the differences between them are highlighted in reverse video. Each file's sector number is given at the top of the window with the file contents presented below in the same form as for the CFILE utility. The program automatically displays the first difference found and further disparities may be located by using the PgDn key. The END key will display the last page where data exists in both files.

Disk Utilities

CDIR is the alter ego of MS-DOS's DIR command, but has far more flexibility. This utility may be invoked with either a drive or a file specification parameter. If a drive parameter is given, the directory of that drive will be displayed. Alternatively, a file specification containing wild cards may be used. In this case, all the files which fall under this designation will be shown. So, for example, CDIR A:*.TXT will present all the files on drive A which have the extension .TXT. Once a directory has been listed on the screen, it may be sorted by file name, extension, file size or date, and time of creation by pressing a function key. Odd numbered function keys (e.g., F1, F3, etc.) will sort in ascending, the even keys in descending, order. Only the files in the current directory may be accessed.

CSORT is the more powerful version of CDIR. This utility will sort file contents on up to five key fields, display the reorganized data and allow the user to browse through the file. It is slightly more complicated to use than most of the other programs in this package, as the parameters can become quite numerous.

If a single file name is called with CSORT, the data in the file is sorted on the first twenty columns and is then displayed. The reorganized information can be redirected by specifying the output file as a second parameter. If desired, sort fields may be defined explicitly by specifying the beginning and ending columns on which the sort is to be based. Up to five pairs of column values may follow the file names and the information in the file will be processed by a sort-within-a-sort arrangement. For example, the command:

CSORT STUFF.TXT SORTED.TXT 1 6 12 15

will create the file SORTED.TXT which contains the information in STUFF.TXT sorted first by the data in columns 1 through 6 and then by the data in columns 12 through 15.

CSORT is more versatile and convenient than the SORT filter in DOS 2.0, which can sort in two orders: alphabetically forward and reverse. It is possible to specify one field parameter per SORT command, so sorting by file extension, date, and so on can be done with a little column counting, but CSORT makes it painless to rearrange the directory with one keystroke.

The CDISK utility gives extremely detailed information concerning hard disk and diskettes (see figure 1). The command may be followed by a disk drive specification if desired. CDISK will display two types of information: a complete description, in both tabular and graphic form, of the disk media and file allocation table (FAT) or, alter-

The output from this part of the program can be used to locate those areas of the diskette which have been "reserved."

Figure 2b:
Output from CENV, page 2

```
IBM PC Interrupts (Segment:Offset)
#00 00E3:3143 Divide by 0              #01 0070:013F Single Step
#02 F000:F85F Nonmaskable              #03 0070:013F Breakpoint
#04 0070:013F Overflow                 #05 0666:0A49 Print Screen
#06 F000:FF23 ???                      #07 F000:FF23 ???
#08 F000:FEA5 Timer                    #09 F000:E987 Keyboard Irpt
#0A F000:FF23 ???                      #0B 0785:966C Comm 2.0
#0C 0785:966C Comm 2.0                 #0D C800:0760 Disk 2.0
#0E F000:EF57 Diskette                 #0F 0070:013F Printer 2.0
#10 F000:F065 Video IO                 #11 F000:F84D Equipment Check
#12 F000:F841 Memory Size              #13 0666:09BF Disk(ette) IO
#14 0733:005C RS232 IO                 #15 F000:F859 Casette IO
#16 F000:E82E Keyboard IO              #17 0733:009C Printer IO
#18 F600:0000 ROM Basic Entry          #19 C800:0186 Bootstrap Loader
#1A F000:FE6E Time of Day              #1B 0070:0138 Keyboard Break Ctrl
#1C 0666:04FD Timer Irpt Ctrl          #1D F000:F0A4 Video Init Parms.
#1E 0000:0522 Diskette Parms.          #1F F000:0000 Graphics Base 128-255

#20 00E3:0BFB DOS Program Terminate    #21 0598:0180 DOS Function Call
#22 0598:028C DOS Terminate Address    #23 0598:0299 DOS Ctrl-Break Exit
#24 0598:04E2 DOS Fatal Error Exit     #25 00E3:14D4 DOS Abs Disk Read
#26 00E3:1521 DOS Abs Disk Write       #27 00E3:27E7 DOS Terminate (Fix)
```

Figure 2c:
Output from CENV,
page 3

```
   IBM PC Memory Map with 64kb/Line
 * = This Prog.      ? = Unused (RAM)
 m = Monochrome      c = Color/Graphics
 b = BASIC (ROM)     s = BIOS  (ROM)
 . = Empty Memory    f = Fixed DISK(ROM)
 D = DOS Related   2-9= system areas
 Seg: 0   1   2   3   4   5   6   7   8   9   A   B   C   D   E   F
0000: DD333333333333333333332222222***********************************
1000: *******************************************************?????????
2000: ????????????????????????????????????????????????????????????????
3000: ????????????????????????????????????????????????????????????????
4000: ????????????????????????????????????????????????????????????????
5000: ................................................................
6000: ................................................................
7000: ................................................................
8000: ................................................................
9000: ................................................................
A000: ................................................................
B000: mmmm............................cccccccccccccccc................
C000: ................................ffffffff........................
D000: ................................................................
E000: ................................................................
F000: ........................bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbssssssss
 Seg: 0   1   2   3   4   5   6   7   8   9   A   B   C   D   E   F
```

Figure 2d:
Output from CENV,
page 4

```
Program Segment Prefix at: 074B

0000: CD 20 00 50 00 9A F0 FF-0D F0 8C 02 98 05 99 02  |. .P............
0010: 98 05 E2 04 98 05 98 05-01 01 01 00 02 FF FF FF  |................
0020: FF FF FF FF FF FF FF FF-FF FF FF FF 27 07 EA E8  |............'...
0030: BB 0D 00 00 00 00 00 00-00 00 00 00 00 00 00 00  |................
0040: 00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00  |................
0050: CD 21 CB 00 00 00 00 00-00 00 00 00 00 20 20 20  |.!............
0060: 20 20 20 20 20 20 20 20-00 00 00 00 00 20 20 20  |          .....
0070: 20 20 20 20 20 20 20 20-00 00 00 00 00 00 00 00  |        ........
0080: 00 0D 0D 6E 0D 64 0D 31-32 2C 65 2C 37 2C 31 2C  |...n.d.12,e,7,1,
0090: 70 0D 6F 20 73 74 61 72-74 0D 2D 2D 2D 2D 2D 2D  |p.o start.------
00A0: 2D 2D 2D 2D 2D 2D 2D 2D-2D 2D 2D 2D 2D 2D 2D 2D  |----------------
00B0: 2D 2D 2D 2D 2D 2D 2D 2D-2D 2D 2D 2D 2D 2D 2D 2D  |----------------
00C0: 2D 2D 2D 2D 2D 2D 2D 2D-2D 2D 2D 2D 2D 2D 2D 2D  |----------------
00D0: 0D 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00  |................
00E0: 00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00  |................
00F0: 00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00  |................

F00D:FFF0 at #06 CALL Dispatcher
0598:028C at #0A Terminate
0598:0299 at #0E Ctrl-Break
0598:04E2 at #12 Critical Error
Memory. Total No Seg=5000
```

natively, the contents of the disk may be inspected on a sector–by–sector basis. Function Key 1 will toggle the program between the two modes.

The program initially displays two (or more, depending on the size of the diskette) pages of data describing the drive type, complete information on sectors and clusters, and a graphic display of the contents of the disk media derived from the cluster information found in the FAT (see figure 1). Some of the descriptions of the representation codes are not well–explained in the manual. "Unassigned 0,1" refers to the first two clusters on the diskette, which are not accessible to the user. (They contain the boot directory, the FAT, and the directory.)

The DISASM utility performs the obvious function of disassembling executable code files and, in addition, will disassemble specified areas of memory.

The output from this part of the program can be used to locate those areas of the diskette which have been "reserved." There are two uses for this designation: to hide bad tracks and to copy protect a program. IBM software usually uses a "bad" code to specify bad sectors; other software may use the "reserved" code. The "reserved" code can also be used to hide program data and information. Sectors which have been assigned to files are displayed using an alphabetic code, thus the location of each section of a file can be instantly ascertained. This utility can be used to check for highly fragmented files. Copying files with non-contiguous clusters onto a fresh diskette will help minimize diskette access time.

You can designate any cluster

as a starting point for viewing the disk contents by positioning the cursor to the desired FAT entry on the graphic display and then pressing function key 1. If no cluster is specified, the default is sector zero. CDISK can inspect the contents of a diskette, even if the directory has been lost and, because the screen can be printed or redirected, a hard

CMEM will display the hexadecimal and equivalent ASCII information of any selected area of memory.

copy of lost files can be obtained. The format, which is the same as CFILE, necessitates retyping the data in this case, but at least the information can be recovered. Most utilities which can unerase lost files can only do so if there is a directory to consult.

Miscellaneous Utilities

The CFILE program mentioned above has a counterpart in CMEM. This utility will display the hexadecimal and equivalent ASCII information of any selected area of memory. The desired memory segment is specified when invoking the program and can be paged through with the same keys as the other utilities in this package. Only one segment (64K) at a time can be viewed; paging is not continuous through memory. The segment can be specified in either hexadecimal or decimal and the screen an be dumped to the printer.

The DISASM utility performs the obvious function of disassembling executable code files and, in addition, will disassemble specified areas of memory. If a file is to be disassembled it is given as the argument to the DISASM command and the disassembled code is output to a file with the same name with an .ASM suffix. To access areas of RAM or ROM, three parameters are required: the memory segment, the starting, and the ending offset. These may be specified as either hexadecimal or decimal values. The output is sent to a file named SEG#nnnn.ASM.

There is a 32,000–byte limit on the file size and a long file takes a minute or two to be processed. If any code produced is considered "ambiguous" by the program, comment lines are inserted to describe the problem. I disassembled three code files and never found a message of any kind; the description of ambiguous code is left somewhat ambiguous.

CENV is used to examine the configuration and environment of the system being used. There are several pages of information (obtained by using the paging keys); although this fact is not terribly obvious from the display. The information presented by this utility is not well–covered in the documentation and is useful only to the advanced programmer who requires specific information regarding file control blocks, interrupt locations, and diskette parameter information. The first page (figure 2a) describes the hardware and memory attached to the system, what types of video cards are installed, and the current and power-up video modes.

The second page (figure 2b) gives all of the PC diskette parameter table values and where in memory these arguments are located. This information is invaluable to programmers who wish to change any of these values.

The third page of CENV (figure 2c) lists IBM PC interrupts one through twenty-seven, alongside their respective segments and offsets. These locations change for some of the DOS routines that must be loaded by the operating system (PRINTER and MODE, for example) and which then change the vectors to point to themselves, making them resident programs.

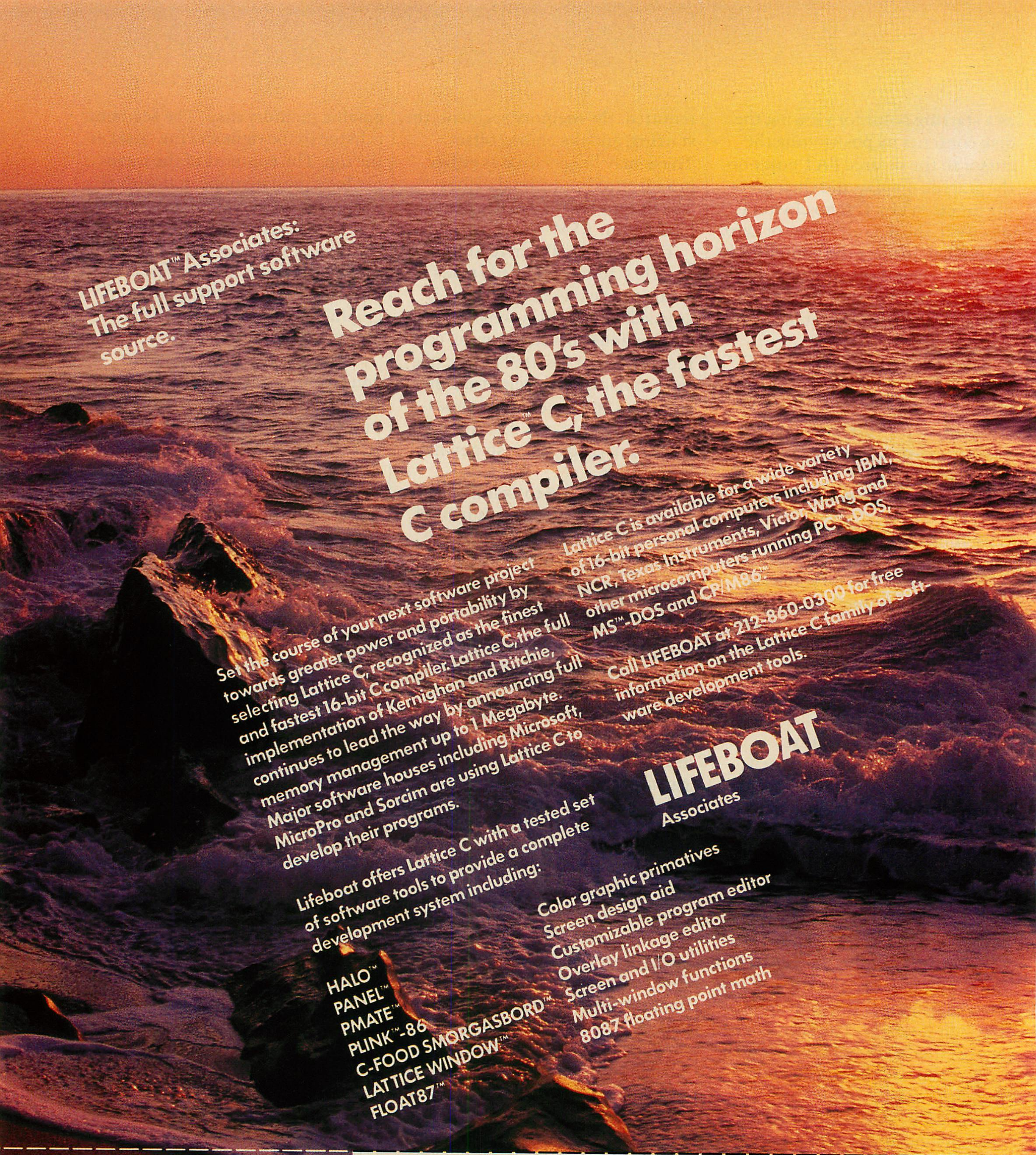
Page four (figure 2d) displays a graphic memory map. The segment is listed to the right and the offset at the top. The contents of the memory locations are indicated with alphanumeric characters, an explanation of which heads up the table. This is useful for seeing the location of all the various parts and pieces of the operating system, graphics, and monochrome displays, hard disk, and so on.

The last two pages are more educational than useful. They display the file control block for the program currently being run, which in this case is CENV. Unfortunately, there is no way to get the file control block for just any old program. The only ones obtainable are for CENV or DEBUG, if CENV is loaded by this utility. The segment and offset for four of the interrupts being trapped by DOS when CENV is running are listed under the display.

Most of the programs in this package provide very detailed information on diskette, hard disk, and memory contents. The advanced programmer will get a great deal of use out of all these utilities. A few

Because all text delimiters are shown in hexadecimal, this program is very useful for finding out what unprintable characters are placed in a text file by word processors.

of the programs, like BROWSE and CDIFF, give the novice and intermediate user a simple introduction to some of the more advanced capabilities of this package. Whether these programs are worth the price of $100 depends on whether the user enjoys looking at the data without being able to directly modify it and, of course, whether good use can be made of the information.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Diskette Cleaning

How to keep them spinning.

TECH NOTEBOOK 7

Will Fastie

Normal preventative maintenance for diskette drives should include periodic cleaning of the read/write heads, especially if the diskette drives have a heavy duty cycle. Head cleaning can be performed by a service technician, but there are also head cleaning kits available from a number of manufacturers that are simple to use.

IBM, BASF, Verbatim, and Scotch 3M, to name a few, manufacture head cleaning diskettes. These diskettes appear to be normal disks, but closer inspection reveals that at least one side of the medium is made of a cloth-like material. Some kits include a cleaning surface. The diskette is designed to be placed in the drive unit; when the disk is spun, it wipes accumulated debris from the head.

In order to produce the cleaning effect, it is necessary to engage the disk drive. The best solution to this problem is a simple program that would attempt to read (or write) the cleaning diskette, all the while ignoring errors. However, such a program is not provided with the IBM PC or its associated software, so another method is needed.

There is a very simple way to make the disk spin on command. First, boot DOS. Place the cleaning diskette in the desired drive. For this example, assume drive B is to have its heads cleaned. Issue the DOS command B:FRED DOS will attempt to load the program FRED from disk drive B. This process will obviously cause the diskette to spin. Because the cleaning diskette has no data recorded upon it, DOS will soon (after about 10 seconds) complain of a failure on that diskette drive. At that juncture, the now-famous message, Abort, Retry, Ignore? will appear.

The next step depends on the instructions for the particular brand of cleaning disk employed. Each manufacturer recommends a specific amount of time for the cleaning process; 30 to 60 seconds seems to be the popular range. To accumulate more cleaning time, type R to make DOS retry the disk operation and, therefore, spin the diskette some more. When the cleaning process is complete, type A to make DOS give up and return to command level.

Repeat this process for each drive in the system. Note that the presence of the DOS disk is not required, so this technique works perfectly well on systems with a single disk drive.

For those of you who would prefer a program, the listing provided here will spin the desired disk drive for a specified length of time. It takes an XT running DOS 2.0 and BASIC about 6.5 seconds to time out a diskette drive. This fact is used by the program to determine how many iterations to perform to cause the disk to spin for the specified time. The actual time may vary by a few seconds.

Be sure to check with your dealer or other reputable service organization for a recommendation as to the particular type or brand of head cleaner to be employed. In fact, be sure the company maintaining your system approves of the brand you intend to use, as their service policy probably does not include repairs required because of negligence or abuse.

This is one thing not to skimp on: obtain the highest-grade product available. An inferior or defective cleaning device can damage the heads or the head positioning mechanism, and result in expensive repairs.

LISTING A PROGRAM TO SPIN DISKETTE DRIVES

```
100 'Program to spin diskette drives for cleaning purposes
110 'Will Fastie -- 11 July 83 -- SPINNER.BAS
120 CLS: KEY OFF
130 PRINT "To end the program, depress ENTER when asked for drive letter."
140 ON ERROR GOTO 290
150 PRINT
160 INPUT "Enter letter of disk drive to spin:  ",D$
170 IF LEN(D$)=0 THEN GOTO 260
180 D$=LEFT$(D$,1): D$=CHR$(ASC(D$)+32*(D$>"Z"))
190 PRINT "Enter number of seconds to spin  ";D$;":  ";
200 INPUT "",S
210 IF S <= 0 THEN BEEP: GOTO 190
220 ITERATIONS = INT((S+6.49)/6.5)
230 OPEN D$+":FRED" FOR INPUT AS #1
240 ITERATIONS = ITERATIONS - 1
250 IF ITERATIONS = 0 THEN GOTO 150 ELSE GOTO 230
260 '----- Exit program
270 CLOSE
280 SYSTEM
290 '----- Routine to handle diskette I/O errors
300 RESUME NEXT
```

System Overview

ETHER SERIES

Ethernet arrives for the PC.

Bruce W. Churchill

In the first article of this series we discussed the implementation of a baseband, bus architecture, CSMA local area network—PCnet. This month we will focus on a similar type of LAN, but one that implements the existing and relatively well-known Ethernet specification. Ethernet was developed by the XEROX Corporation and has become an early de-facto standard for local area networking. Ethernet is also the basis for one of the technologies chosen for the IEEE-802 Local Area Network specification, currently undergoing definition.

Overview

EtherSeries is a hardware and software package that connects IBM PCs and allows the sharing of mass storage and printer resources. EtherSeries is the first IBM PC local area network designed to Ethernet specifications. It is classified as a baseband modulated, distributed bus topology network, with carrier senses, multiple access contention protocol inluding collision detection (CSMA/CD). EtherSeries uses the PC DOS operating system and is transparent to the user, except for the additional operating system level commands necessary to establish links and manage the flow of information between work stations and shared resources. As few as two or as many as 100 PCs may be connected to a single segment, or a continuous run of network cable terminated at both ends. Because Ether–Series is an Ethernet-compatible LAN, it supports multiple segments. These segments are connected by devices known as repeaters, which make several physical segments appear to be one logical network. A maximum size Ethernet extends for 2,800 meters end-to-end. EtherSeries is also compatible with other Ethernet components such as repeaters, fibre-optic transceivers, communications servers and network peripheral resources.

EtherSeries and LAN Standardization

In order to provide a better perspective on EtherSeries hardware and software and its relationship to the Ethernet specification, let us briefly discuss the concept of a layered architecture for the management of data communications. Why is such a concept so important? Simply because of the complexity of data

> *EtherSeries is a hardware and software package that connects IBM PCs and allows the sharing of mass storage and printer resources. It's the first IBM PC local area network designed to Ethernet specifications.*

communications and the economic motivation of standardization. The best known such architecture is illustrated in figure 1 and is commonly known as the International Standards Organization (ISO) 7-layer model for Open Systems Interconnection, or ISO-OSI for short.

The standardization of protocol, or rules of behavior between equivalent ISO-OSI layers on dis-

Bruce Churchill has worked in data communications for the Navy for 13 years and been involved in the micro field for five years. He is author of the book from Robert J. Brady, Communications and Networking for the IBM PC.

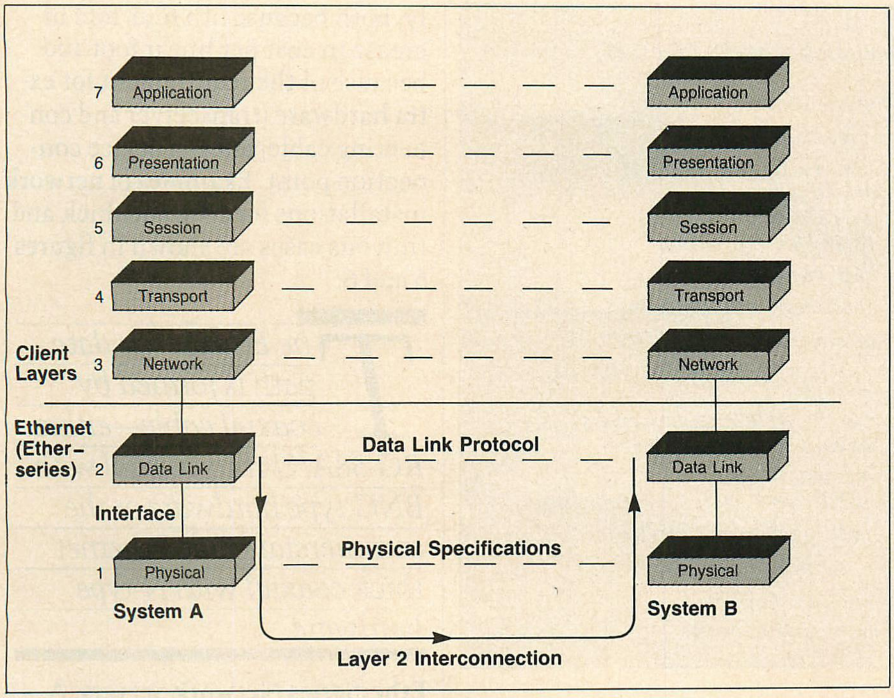

Figure 1: ISO-OSI 7-Layer Communications Model

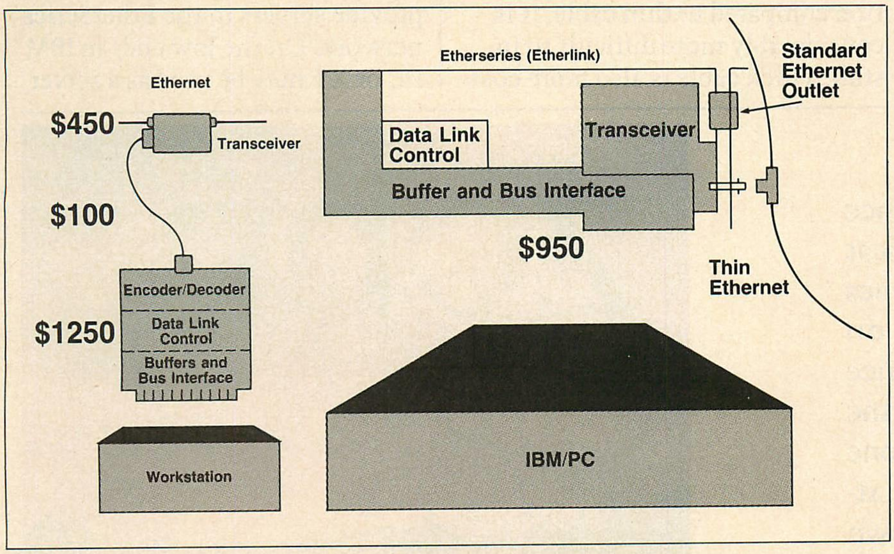

Figure 2: Ethernet-to-EtherSeries Transition

similar systems is still in progress, with only the lower layers (1–3) well established. The Ethernet specification in particular addresses only layers 1 and 2 as shown in figure 1. The significance of standardization might be better understood by looking at the process of communicating data between two dissimilar systems. Figure 1 shows two systems logically interconnected through the data link layer, illustrating compatible data link and physical layer protocol and specifications. The client layers (3–7) in both systems may be dissimilar but should see the same interface from the data link layer, even if the details of implementation differ.

The economic benefits of this piecewise standardization are realized through lowered costs of producing components to carry out functions in a given layer or layers. EtherSeries is a case in point. Because there is a standard specification for Ethernet in layers 1 and 2, data link functions could be reduced from many components on a VAX controller card to a single logic chip on the IBM PC adapter card. The result has been close to a 50 percent price reduction to implement an Ethernet compatible controller card. This price reduction is graphically illustrated in figure 2.

EtherSeries Hardware

The hardware associated with EtherSeries is composed of network bus components, Etherlink adapter cards, and the EtherShare network server. Each of these will be discussed next in more detail.

Network Bus Components. The EtherSeries data path is formed by coaxial cable—either RG-58A/U thin coaxial with BNC-type hardware or the commercial grade Ethernet thick coaxial with N-type hardware. Thin cable can be connected directly to the adapter card with a BNC T-connector, as shown in figure 2. Thick cable requires an external transceiver, a cable tap, and a transceiver cable. Figure 3 illustrates a typical Ethernet configuration and its relationship to component functions and ISO model layers. The relationship between Ethernet and EtherSeries is shown

Because there is a standard specification for Ethernet in the layered communications architecture, data link functions could be reduced from many components on a VAX controller card to a single logic chip on the IBM PC adapter card.

in both figures 2 and 3. Thick and thin cable may be intermingled on the same network as long as basic network configuration rules are followed. These rules, which conform to Ethernet specifications, are sum-

Table 1: The Twelve Commandments Of Ethernet

I.	100 nodes maximum on any single segment
II.	Nodes must be at least 2.5 meters apart
III.	Node is defined as an addressable entity connected via: • Cable Tap (T-connector for thin cable) • Transceiver (on adapter card for thin system) • Controller (on adapter card for thin system)
IV.	Any number of devices may be connected to a node
V.	Repeaters may be placed at any or every node position
VI.	Maximum length of cable between any 2 nodes = 1500m
VII.	Maximum segment length: • 300 m Thin Ethernet • 500 m Thick Ethernet with non-3Com transceivers • 1000 m Thick Ethernet with 3Com transceivers
VIII.	Maximum length of transceiver cable = 50 m (Adapter card to thick cable transceiver)
IX.	Maximum of 2 repeaters in a path between any 2 nodes
X.	Maximum of 1000 m for a point-to-point link
XI.	Maximum end-to-end network length = 2800 m
XII.	Maximum of 1024 nodes on a complete network

marized in table 1. Figure 4 shows a maximum configuration conforming to the Ethernet specification. Although thick cable allows longer segments and has better RF isolation compared to thin cable, it is considerably more difficult to install. Thick cable is also more costly, both because of a four-fold increase in cost per linear foot and because of the requirement for extra hardware (transceiver and connecting cable) at each device connection point. Examples of network installations for both the thick and thin bus cases are shown in figures 5 and 6.

The EtherSeries data path is formed by coaxial cable—either RG-58A/U thin coaxial with BNC-type hardware or the commercial grade Ethernet thick coaxial with N-type hardware.

EtherSeries Network Servers. A range of computer types exists to provide servers to the EtherSeries network. On the low end, an IBM PC or XT may be used as a server,

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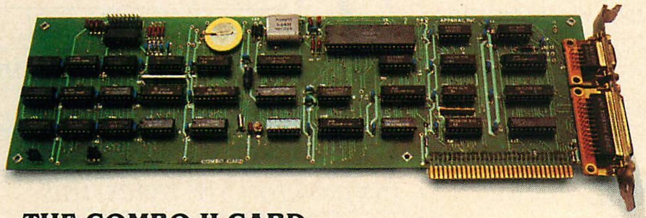

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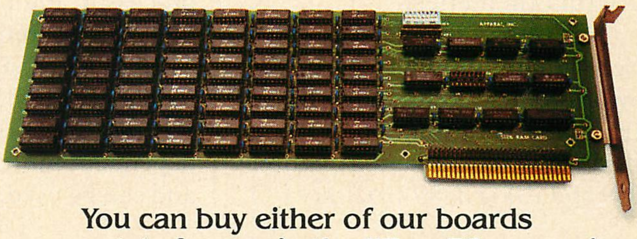

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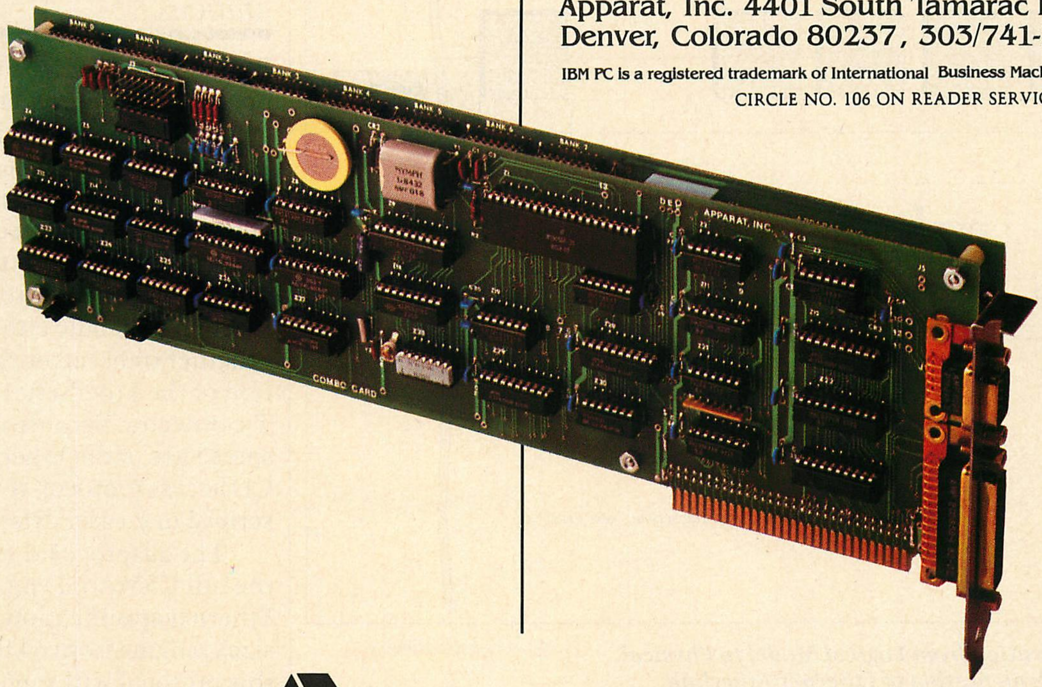

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providing 10 megabytes of hard disk and up to two printer resources to the network. This server is designed to handle about 8-10 users. For larger networks, a modified Altos 586 is used to provide a selection of 30 or 60 megabytes and up to two printers to the network. It is also capable of controlling a modem that acts as a remote dial-in server for advanced electronic mail applications. The high end of the server family is the DEC VAX 750, which is an appropriate choice for organizations with such a computer installed on the premises. The VAX server must be using Version 4.1 of UNIX in order to be compatible with EtherSeries.

The Altos 586 is worthy of a discussion in its own right. It is a powerful microcomputer, with a 10 MHZ 8086 as the main processor. The 8086 is accompanied by Intel 8089 and Zilog Z-80 auxiliary I/O

A range of computer types exists to provide servers to the EtherSeries network, from the IBM PC or XT to the modified Altos 586 to the DEC VAX 750.

processors. The 8089 is used for hard disk and tape cartridge control and the Z-80 for floppy drive and asynchronous port control. A 1-megabyte floppy disk is integral to the 586 for hard disk backup. A communications board contains Ethernet circuitry, an Intel 80186 processor, and 128K of RAM. The 586 main system board contains 512K of RAM. The Altos 586 runs under the XENIX operating system—in effect this server is an independent multi-user workstation and can be used as such.

Adapter Card. Each device, or node on the network, must have an EtherSeries network adapter card installed. The adapter card contains the circuitry and firmware required to implement Layers 1 and 2 (Physical and Data Link) of the previously discussed 7-layer ISO model. As shown in figure 2, the card includes a transceiver, which is capable of driving the thin Ethernet cable. As previously mentioned, the thick Ethernet installation requires an external transceiver, which is available from several suppliers in addition to 3Com or XEROX Corporation. The adapter card is responsible for four functions that are required for proper network operation: interface to the host processor and RAM, data encapsulation into

The adapter card implements the full CSMA/CD protocol in the Ehternet specification. With packet sizes ranging from 64 to 1518 bytes, this protocol will support a network configuration of up to 2.8 km between any two work stations.

Ethernet packets (and the reverse operation), data link layer control (contention protocol algorithms), and the physical processes required for the transmission and reception of baseband modulated data. Figure 2 shows the layout of the adapter card by function. Note that the card is set up to handle either standard Ethernet transceiver cable connection or the EtherSeries BNC type–T-connector. Because of the widespread use of the Ethernet CSMA/CD access protocol, it will be described in greater detail.

The adapter card implements the full CSMA/CD protocol in the Ethernet specification. With packet sizes ranging from 64 to 1518 bytes, this protocol will support a net-

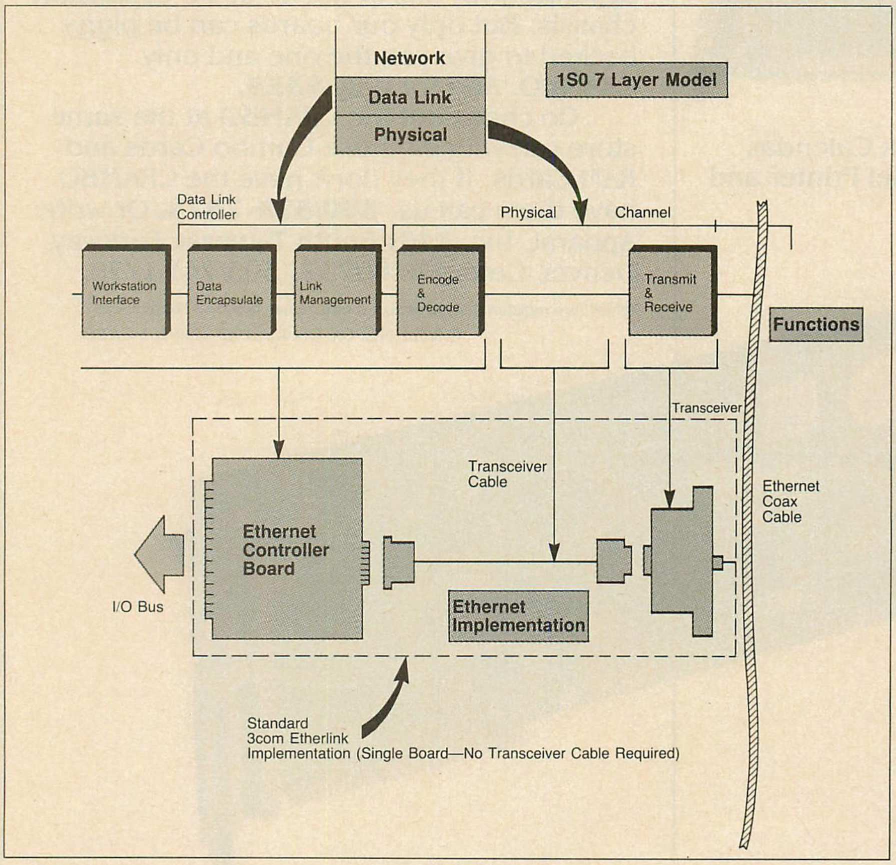
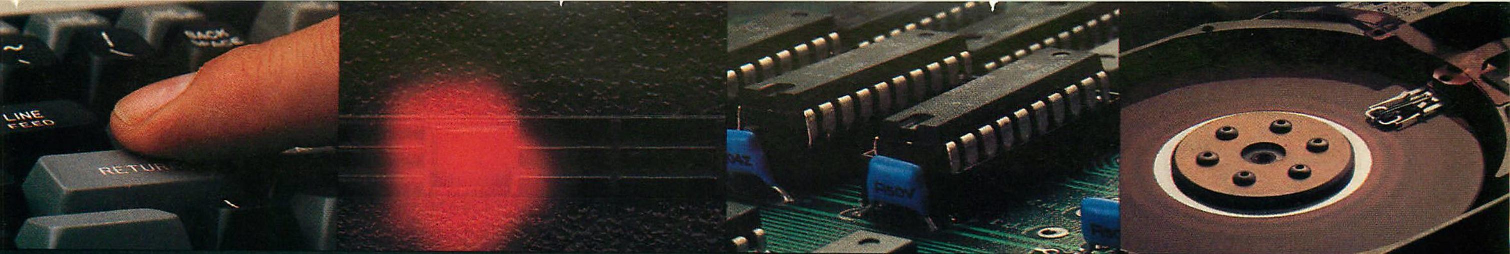


Figure 3: Transition from Logical Model to Physical Implementation of Ethernet/Etherlink



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work configuration of up to 2.8 km between any two work stations. A multisegment Ethernet (or EtherSeries) LAN is shown in figure 7; the Ethernet packet format is shown in figure 8. The maximum packet size is based on efficiency and the desire to minimize collisions (two or more data packets on the network simultaneously). Minimum packet size is chosen to guarantee collision detection (CD) at maximum network sizes. Figure 9 illustrates how minimum packet size and maximum network size interact to provide collision detection under the worst case condition.

The time required to transmit 64 bytes is 51.2 microseconds at a 10 megabit data rate. This is approximately equal to the time required for a bit of data to make the round trip between two PCs at the network extremities in figures 7 and 9. If PC A commences a packet

Each device, or node on the network, must have an EtherSeries network adapter card installed.

transmission on the network, B will not sense the carrier until A's packet begins to arrive. If PC B were to start a transmission just prior to the arrival of A's packet (which would be allowable with the CSMA/CD protocol), a collision would be generated at B when A's packet arrives. B would then transmit a collision signal, which would begin to arrive at A while A was still transmitting the original 64-byte packet. Thus the adapter card in A would also detect a collision and begin its collision recovery routine. In the recovery routine, the PC continues transmission for a short interval in order to generate the collision signal—known as a jam transmission—which is followed by a random silence period, before it reattempts sending the packet. Because this is the worst case example, any longer packet size or any two nodes closer together on the network will also have guaranteed collision detection.

This logic is the most difficult part of the CSMA/CD protocol to comprehend. The remaining aspects of this access control method are relatively straightforward. If the physical layer of a station does not sense a carrier, it signals the data link layer to send it one or more Ethernet packets. On a baseband network such as EtherSeries, a "carrier" is actually the presence of digital signal transitions (1 to 0 and 0 to 1) from bit-to-bit. Once the packets are transmitted, the collision detect logic works as just described. With Ethernet packet sizes, the percentage of collisions is quite low (less than 1 percent), even on relatively large and busy networks (in excess of 100 work stations). The end result is that a business user of EtherSeries or similar LANs need not be overly concerned about degraded performance due to collisions.

EtherSeries Software. EtherSeries software is available in four separate packages: EtherShare, EtherPrint, EtherMail, and Remote EtherMail. Each of the packages operates both on network servers and on user PCs. EtherShare and EtherPrint user software is provided on a distribution diskette with the basic EtherLink network adapter card kit. Purchase of the EtherSeries network AP server includes EtherShare/AP server software. EtherShare/PC software is distributed separately if the use of IBM PCs or XTs as servers is con-

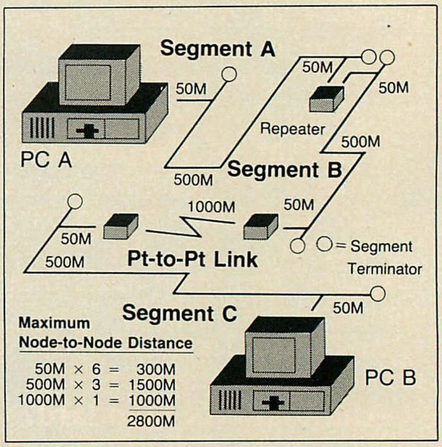

Figure 4: Multi-Segment Ethernet (Maximum Size)

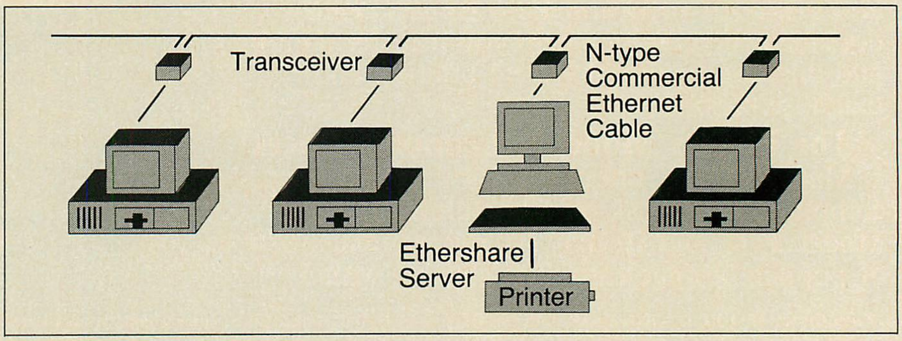

Figure 5: Thick Cable EtherLink (with EtherShare/AP)

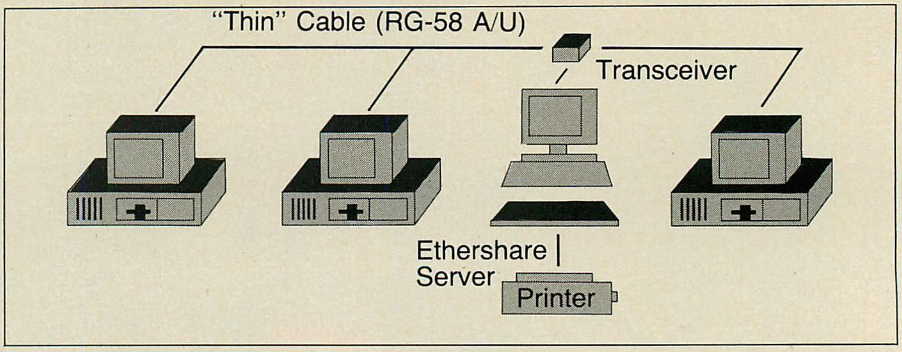

Figure 6: Thin Cable EtherLink (with EtherShare/AP)

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templated. EtherPrint and EtherMail are optional software packages for either the PC or AP network servers. The optional EtherMail software is provided for both the appropriate server and user PCs. Each

EtherPrint is supplied as a software utility package that runs on EtherShare/PC or AP servers, and on user PCs.

user PC downloads its EtherMail software from an associated server. Remote EtherMail software is an optional add-on for each remote PC or XT desiring to access the EtherSeries network.

EtherShare Software. The use of EtherShare in the EtherSeries network adds a new dimension to its utility in the business environment. Hard disk drive management requires the installation of the EtherShare software package. Hard disk drives are provided by 3Com Corporation with the EtherShare/AP server—other types of IBM PC compatible drives or the IBM XT are supported by EtherShare/PC software. EtherShare is made up of three distinct parts:

- The EtherShare server, which manages all EtherShare resources such as hard disk volumes and printers
- The EtherShare administrative program, which performs housekeeping jobs on the server
- EtherShare commands, which execute from a command file on each user PCs local drive (usually A:)

There are 14 EtherShare commands accessible by each user on the EtherSeries network. These commands allow the user to

- Log-in and Log-out from the

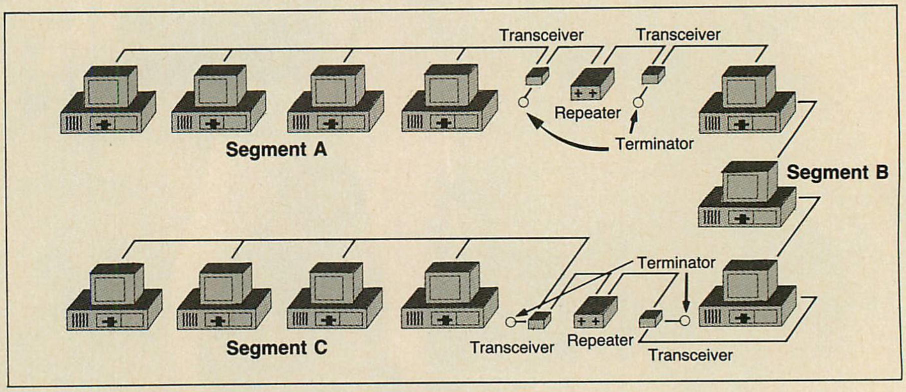

Figure 7: Multi-Segment Ethernet (or EtherSeries)

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server by user name

- Create or delete EtherShare volumes and network users
- Link and unlink local floppy drive designators to EtherShare volumes
- Modify user access and volume parameters
- Display directories of network users and volumes
- List servers in use
- Receive help on any EtherShare command

Volumes ranging in size from 64K to 32K can be established on the hard disk. Any user on the network can link one to four local drive designators to the EtherShare server. The allowable drive designators are C:, D:, E:, or F:. Drives A: and B: are reserved for local floppy devices.

A single user may only establish one set of links (drive designators to volume names) to a given server at a time. Over the entire network, however, any number of links may be set up from multiple users, up to the limit of the server capacity. The job of the EtherShare server software is to manage the allocation of disk space on the server with multiple users accessing the hard disk.

Table 2: EtherShare Volume Protection

Type	Volume Access	Password Assigned	No Password
PUBLIC	Shared, read-only access	Password required	Anyone can use
PRIVATE	Only one user can access (exclusive access)	Password required	Only the creator may use
SHARED	Multiple users with read/write access	Password required	Only the creator may use

File protection is accomplished by passwords and a simple scheme of access control. Protection is provided only to the volume level of storage. Individual files and records are not protected. A volume can be public, private, or shared. If public, everyone on the network has read only access; if private, only the creator of the volume has access. Shared volumes allow multiple users to read and write to the volume simultaneously. Passwords can be assigned to any volume. Table 2 summarizes the protection scheme managed by EtherShare software.

To clarify the server process on the EtherSeries network, let us create a volume on the shared hard disk and link a local drive specifier to that volume. We will first log in to our server, which has previously been set up as SERVER1, with the user name BRUCEC. Our volume will be named WORDPROC and it will be a public volume with the password HELLO. WORDPROC will be linked to our drive designator C:

A)ES LOGIN ?
YOUR NAME? BRUCEC
BRUCEC logged in to SERVER1
Your EtherShare drives are C: through F:

This could also have been entered in the non-prompted mode as:

A)ES LOGIN BRUCEC

We will now create the volume WORDPROC:

A)ES CREATE ?
Name? WORDPROC
Password? (HELLO)
(password is not displayed)
Size? /2
(set up as a double-sided diskette)
WORDPROC created
Formatting . . .
(user feedback)
WORDPROC formatted
(confirmation)

WORDPROC is automatically created as a private volume. Since we would want to make this a public volume, the ES MODIFY command would be invoked and the access parameter changed to /PUB. In order to link drive specified C: at our user PC to WORDPROC, the following dialog ensues:

A)ES LINK C: WORDPROC
(non-prompted command entry)

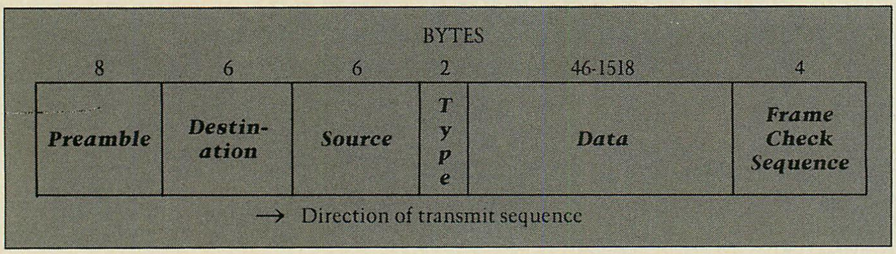

Figure 8: Ethernet Packet Format

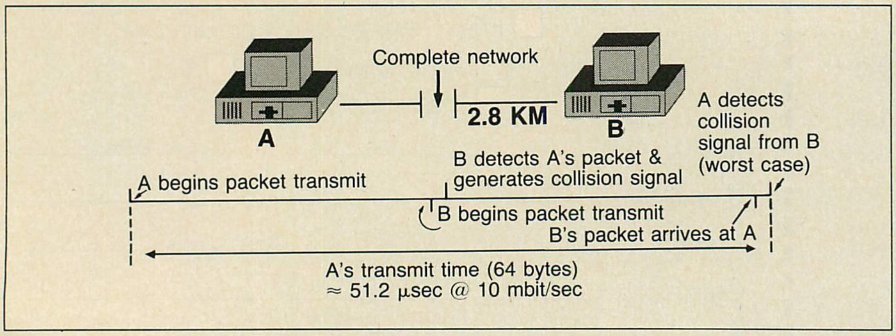

Figure 9: Ethernet Collision Detection

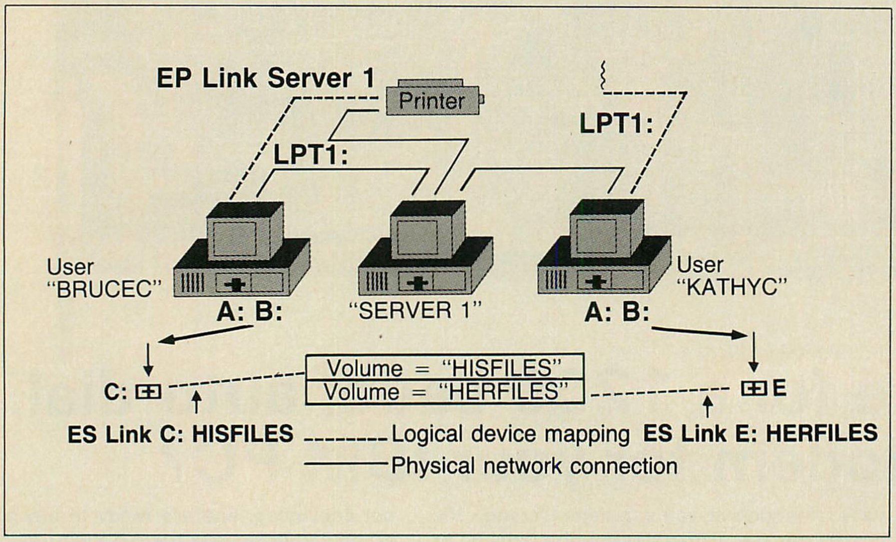

Figure 10: Basic EtherSeries Resource Sharing (with IBM XT Server)

WORDPROC linked to C:
(confirmation)
Compatibility of existing IBM PC software must be examined carefully prior to the planning of any major network applications. In general, for a software package to be compatible, it must:

- run under PC DOS 1.1 or 2.0
- use standard DOS floppy disk and printer drivers
- be relocatable in user RAM
- have program and data that leave about 5400 bytes of RAM for EtherSeries drivers when loaded
- not depend on linking to EtherShare volumes while running (equivalent to requiring a diskette insertion while running). All required files must be linked prior to execution

Any packet size longer than 64 bytes will have guaranteed collision detection, so business users need not be overly concerned about degraded performance due to message collision.

Software known to be compatible with EtherSeries network operation includes WordStar, VisiSeries, SuperCalc, pfs:, EasyWriter 1.1, and dBASE II. Another consideration in using existing sotware is autobooting requirements for certain programs. VisiSeries Programs fall into this category. In order not to break existing links, these programs should be booted with the AUTOEXEC command and not with CTRL-ALT-DEL.

The final topic to be discussed under EtherShare is the concept of semaphores. A semaphore is a symbolically named lock that provides a BIOS-level primitive for multiuser file updating applications. It should be emphasized that such a scheme must be integrated into a user's application software package before it has any practical value. Three primitives are supplied as part of EtherShare: LOCK/WAIT, LOCK/RETURN, and UNLOCK. These primitives can be set up to provide locking to both record or file levels. LOCK/WAIT is a try-until-free service, while LOCK/RETURN provides an immediate status to the requesting program. Up to 50 locks may be maintained on a server at any one time. At this point the reader should be aware that the development of multi-user applications software in a networking environment is not a trivial task. Several such packages are now becoming available and will make networking a significantly more valuable resource to the business community.

EtherPrint. EtherPrint is supplied as a software utility package that runs on EtherShare/PC or AP servers and on user PCs. It performs in similar fashion on either type of server. The commands to link and unlink printer resources are identical. The major difference is that EtherPrint/PC supports the use of parallel printers on the server, while EtherPrint/AP supports only serial printers. All print files are queued in the EtherShare server on a first-in, first-out basis until the selected printer is available. Once a printer link is established between a PC and a print device, normal PC DOS or BASIC print commands can be executed on the selected printer.

With EtherMail you can get mail from a network "post office," and send, reply to, forward, file, print, or save messages.

The following sequence will illustrate the use of EtherPrint to print a preliminary report on a draft-quality printer attached to the server, named SERVER2. The report has been prepared with WordStar. The first step is to establish the printer link:

A)EP LINK?
Your printer ID? LPT1:
(what printer device to link)
To whom? SERVER1
(designate the proper server)
Your name? BRUCEC
(enter EtherShare user name)
SERVER 1 linked to LPT1:
(confirmation of link)

In the event that a review of EtherShare printer assignment is desired, the following sequence will list printers attached to the server:

A)EP DIR SERVER2
(list printers on server SERVER2)

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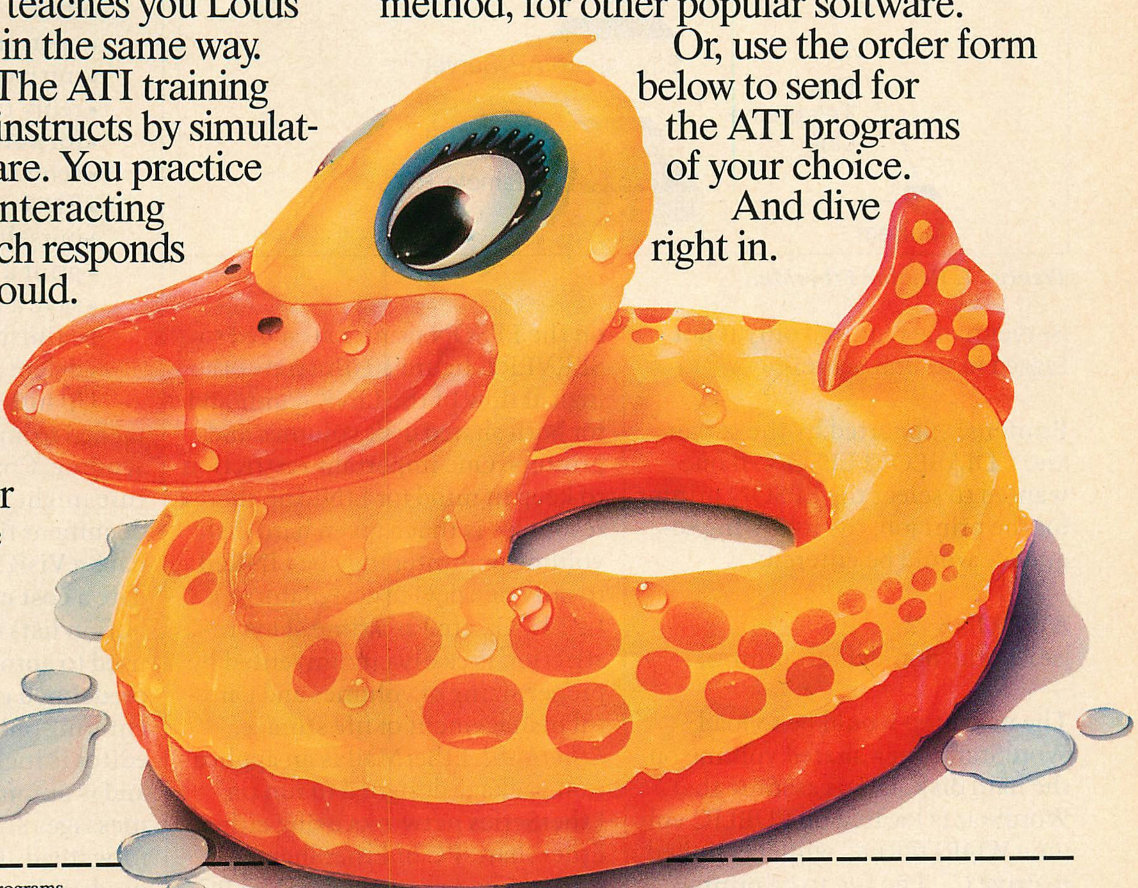

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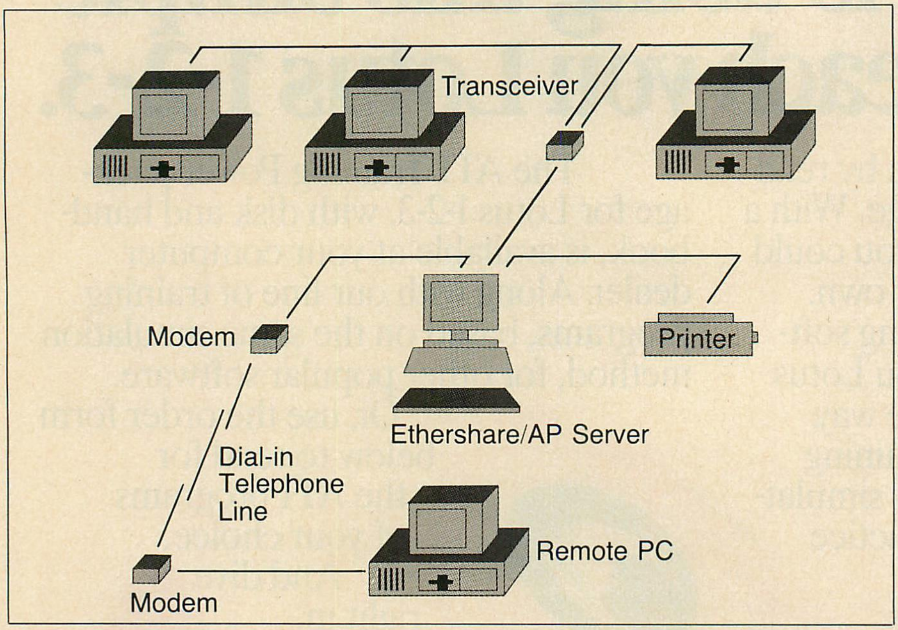

Figure 11: Remote EtherMail

(server name required only if not logged in to that server)

Printer(s) supported by the server are: 1 DIABLO, 2 EPSON. If one wanted to select the EPSON printer for the print job, the following sequence would be entered:

A)EP LINK /2
(select the non-default printer)

The next step would be to load WordStar from a shared volume on the hard disk. Let us assume that WordStar is located on PUBLIC volume WORDPROC which is linked to drive C:. The file to be printed, REPORT.DOC, is on PRIVATE volume MYFILES which is linked to drive D:.

A)C:WS
(Load WordStar from the hard disk)
P
(Print file from "Edit No File" menu of WordStar)
Name of file to print?
D:REPORT .DOC
(Now answer the print file questions as desired)
Ready printer, press Return

The report file on hard disk volume MYFILES will now begin printing on the EPSON printer attached to SERVER2. figure 10 illustrates the logical flow of the LINK command for both shared disk volumes and printers. One important restriction to keep in mind for LINKing shared resources is that a given hard disk volume or printer may be LINKed to only one device designator (e.g. LPT1:, C:, etc.) at a time. This restriction is easily circumvented by proper sizing of volumes and careful management of file storage.

EtherMail. EtherMail is an application package designed to run on EtherSeries networks using either EtherShare/PC or EtherShare/AP software as a prerequisite. The PC or AP servers act as a post office and mail administrator for the network. Each user on the network runs an EtherMail program that provides network electronic mail capabilities to be described next. There are two versions of EtherMail: EtherMail/PC and EtherMail/AP, each running under its respective version of EtherShare. Briefly, both versions of EtherMail allow the network user to:

- get new mail from the "post office"
- open and read a message
- initiate a new message
- reply to a message
- forward a copy of the message
- send a message
- file a message (send it to yourself)
- print a message
- save a message in progress (to be finished later)
- delete a message

Up to 26 DOS files may be attached to an EtherMail message for sending. Common uses of this feature might be a send to WordStar document file for comment or perhaps a VisiCalc budget model to update a cost center's entries. Distribution lists may be created and used to automatically send mail to predefined groups of recipients by entering only a file name. A text editor is included in the software and is automatically invoked when messages are created, replied to, or forwarded. The editor may also be used off-line. Any other editor or word processor may be used and the resulting file sent as an attachment

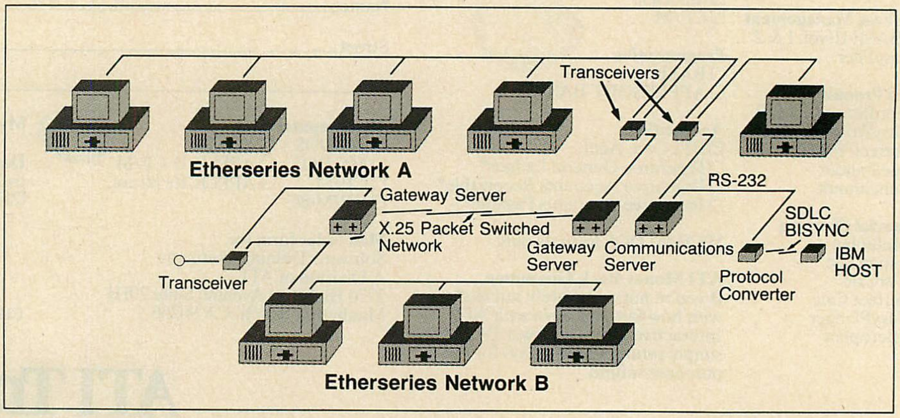

Figure 12: Ethernet-Compatible Servers for Gateway Service on EtherSeries

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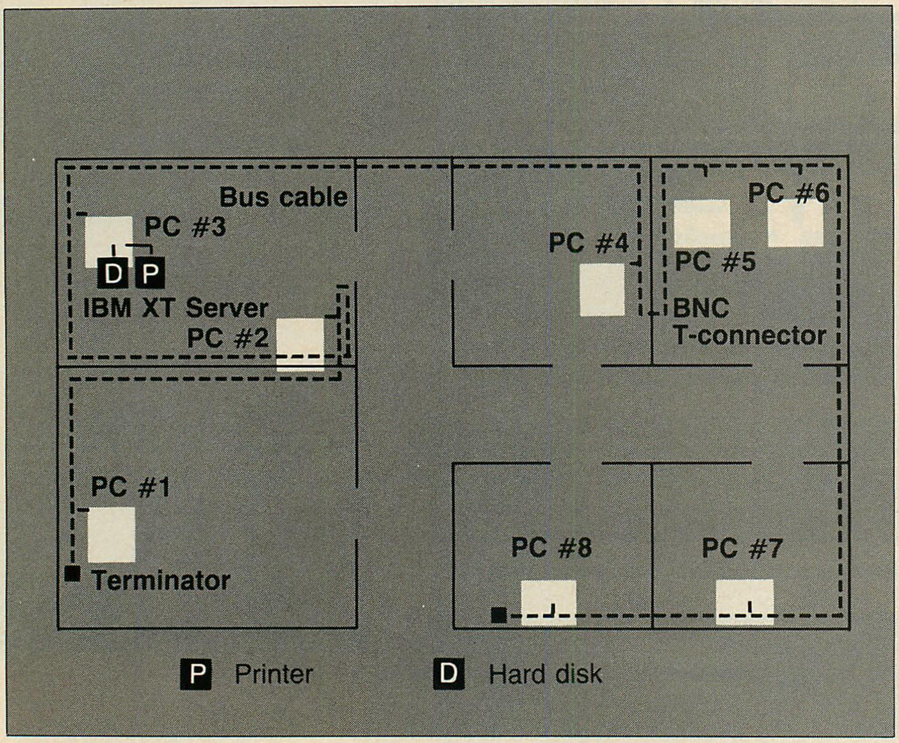

Figure 13: Local Area Network Installation

to a normal message.

The text editor is a full-screen editor that provides a relatively complete capability to compose and modify text. It is not a word processor nor a full-function text editor such as IBM's Personal Editor; however, it is more than adequate for the task of creating and managing electronic mail. Its capabilities include:

- insert and typeover text entry modes
- deletion of characters, words, partial lines and lines
- marking of text for copy, move and delete functions
- tabbed indentation
- automatic word wrap
- paragraph reformatting to the margins after editing
- line and paragraph splitting and joining

Tabs and margins are fixed and cannot be modified. Advanced formatting functions are not supported. However, by use of the attachments composed with word processors that were described earlier, almost any formatting requirement can be accommodated by the system.

The EtherShare server has two primary functions in the EtherMail process: It accepts and distributes a user's messages, checking every server on the network to find the proper addressees. Each active user on the EtherSeries network must be logged on to a specific server if more than one is present. Message routing is accomplished transparently to the user. The server also accepts messages addressed to all its logged-in users, and holds them in the "post office" until recipients desire to retrieve them. In addition, the EtherShare server maintains personal "mail folders" for the users who normally log on to that server. The mail folders are managed by the users, not by the EtherShare "post office."

Remote EtherMail. The EtherMail–AP version supports a single dial-in modem port that allows remote stations to use the server as if they were a part of the EtherSeries network. This is shown in figure 11. All functions available to an EtherSeries network mail user are available to properly configured remote PCs. A remote PC must have 192 K of RAM, run under PC DOS 2.0 operating system, and have a copy of the EtherMail Remote User software. There can be several such remote mail users, limited in practice by the access time available on the single dial-in port on the EtherMail/AP server. This limitation is easily overcome by good network mail management. The single dial-in port will support all servers on the EtherSeries network—in other words, a remote station can send mail to any recognized user (one that has been CREATEd on one of the network servers).

EtherSeries Compatibility with Other Ethernet Systems

As an Ethernet-compatible network, EtherSeries can be enhanced by the addition of a number of products that have been developed for the Ethernet system, among them, network repeaters, both local and remote, communications and gateway servers, fibre-optic links, and laser print services. Ungermann-Bass offers local network repeaters that interconnect Ethernet segments up to 100 meters distant, and remote repeaters that use fibre optic links to provide point-to-point connections of up to 1000 meters in length. Codenoll Technology Corporation has developed a complete Ethernet system using fibre optic transmission technology; this becomes another source for obtaining the 1000-meter fibre optic point-to-point link allowed by the Ethernet specification.

EtherSeries can be enhanced by a number of products, among them, network repeaters, communications and gateway servers, fibre-optic links, and laser print servers.

Envision a single high-speed communications board with integrated easy-to-use software that emulates any terminal.

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At ITI, we know your data communications must be fast, accurate and inexpensive. Our engineers faced the same communications problems you face. That's why they designed Linkup™ for the IBM PC.

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Communication modes support high and low speed access to computing and data base services, electronic mail, order entry, credit verification, tele-conferencing and direct marketing.

Linkup is the only communications hardware you'll ever need.

A single plug-in module with the modular software emulates TTY, ASCII block mode, IBM 3101, IBM 2780/3780, DEC VT 52/100 and IBM 3270 and 5250. Terminal emulation modes are changed by a single keystroke without changing diskettes and switching modem cables. And most importantly, the same familiar user command set appears in all modes.

Linkup grows to meet your changing needs.

Future terminal protocol requirements will integrate into our programmable coprocessor. And, Linkup's high-speed data throughput allows you to take full advantage of increases in common carrier transmission line speeds.

Linkup is cost-effective.

Linkup's single communications board does more than several others combined, leaving your computer's precious board slots open for further applications. And its powerful MC 6809 processor chip handles all communications tasks, freeing the PC to service the user interface.

Faster, more accurate transmission means lower costs.

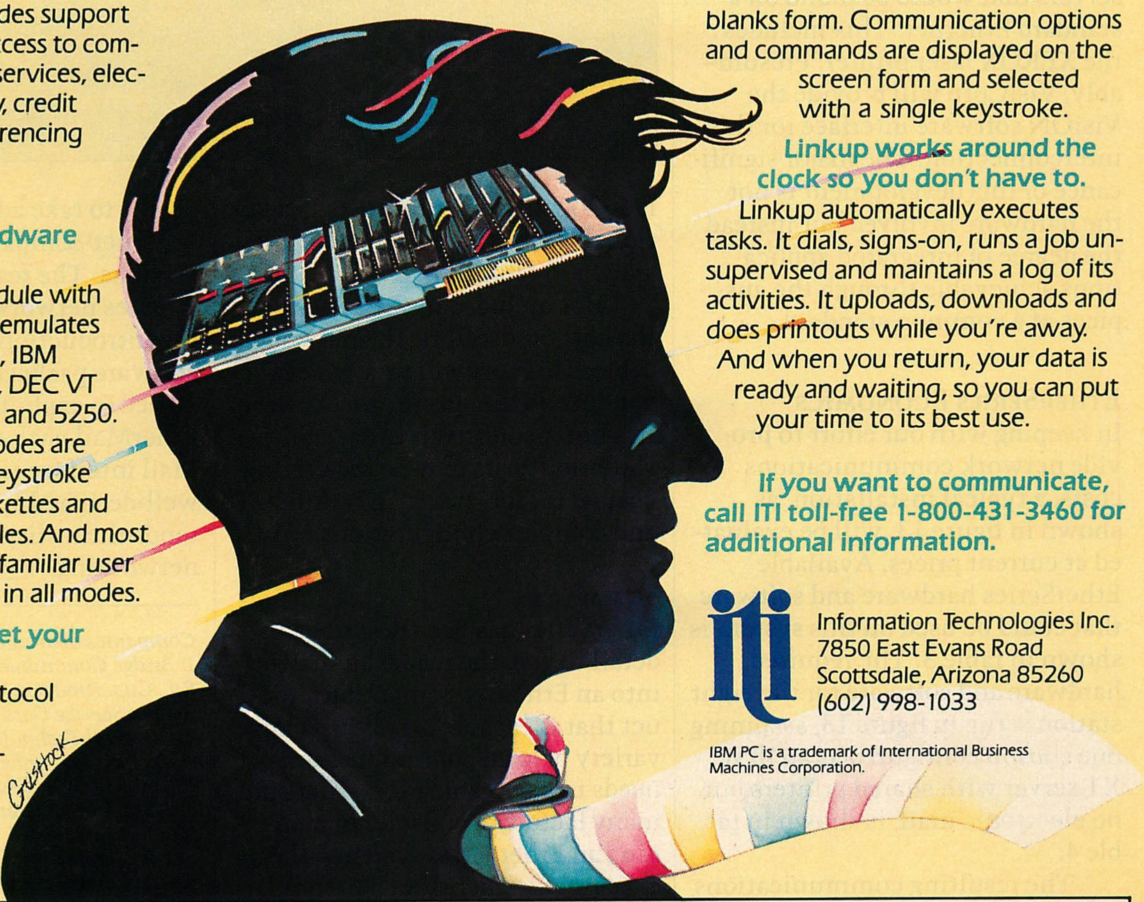
Linkup's integrated design architecture reduces connect charges by transmitting and receiving data at speeds up to 19.2 Kilobaud asynchronous and up to 56 Kilobits per second synchronous without the loss of data throughput normally associated with such speeds. Transfer files at high speed to the PC's disk, then print off-line. And, each line can be checked for error as it's received automatically, retransmitting only those lines in error, instead of entire pages. That saves connect time and character transmission charges.

Our innovative fill-in-the-blanks technique overcomes the tedium of question-answer interrogation and menu approaches.

The user simply enters phone numbers, passwords and job file names on a consistent fill-in-the blanks form. Communication options and commands are displayed on the screen form and selected with a single keystroke.

Linkup works around the clock so you don't have to.

Linkup automatically executes tasks. It dials, signs-on, runs a job unsupervised and maintains a log of its activities. It uploads, downloads and does printouts while you're away. And when you return, your data is ready and waiting, so you can put your time to its best use.



If you want to communicate, call ITI toll-free 1-800-431-3460 for additional information.

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Linkup Specifications

Speed: 56 Kbps Synchronous, 19.2 Kbaud Asynchronous
Terminal Emulation Modes: TTY, ASCII Block Transfer, DEC VT 52/100, IBM 3101, IBM 2780/3780, and future options include 3270, 5250, Tektronix 40XX.
File Types: ASCII, EBCDIC and Binary.
Automatic Modes: Dialup, Log-on, Job Execution, Answer, Alert, Unattended Job Scheduling.
Communications Interface: Dual channel RS232/423 compatible.
Modems: 103, 212, 201, 208 Bell compatible, Hayes, Vadic, Rixon smart modems, or user defined.
Bus Interface: IBM PC bus compatible.
PC Configuration: PC DOS, 64 Kbytes RAM, 160 KB Floppy, monochrome display minimum. Also supports IBM compatible hard disks, color displays and printers.
Options: Printz™ Print Spooler, Postmaster™ Electronic Mail, Audit™ Billing Summary
Base Price: \$795 each, including TTY and Asynchronous block software.

Bridge Communications Inc. has a communications server known as CS/1 that interconnects RS-232/423 devices to an Ethernet. These include terminals, modems, printers and all sizes of computers. This company also has two gateway servers—GS/1 connects two Ethernets via an X.25 packet-switched network or directly converts protocol to allow X.25 and Ethernet communications. GS/2 interconnects Ethernets and provides access to Sytek's Localnet broadband network. Figure 12 illustrates an EtherSeries network configuration with some of the above devices integrated.

A recent announcement by 3Com Corporation, XEROX, and VisiCorp gives IBM PCs on an EtherSeries network access to XEROX servers that would be found on a standard Ethernet. This includes the XEROX laser printer. Presumably, VisiCorp will provide the VisiON software interface for this interconnection. The major significance of this development is not the hardware involved but instead the degree of integrated applications achievable through the auspices of a common standard.

Table 3: Cost of EtherSeries Components

AP Network Server (10/30 Mbyte)	$11500/12500
EtherLink Network Interface	$950
Thin Ethernet Cable	$20 + $1/meter
Thin Ethernet Terminator Kit	$25
Thin Ethernet Loopback Plug	$25
EtherMail/AP Software	$1500
EtherPrint/AP Software	$750
EtherMail/PC Software	$750
EtherPrint/PC Software	$500
EtherShare/PC Software	$500
Remote EtherMail User Software	$100

Table 4: Pricing of Eight Station Configuration (shown in Figure 13)

8 EtherSeries network interface cards (includes T-connectors and software)	$7600
Thin Ethernet Terminator Kit	$25
Thin Ethernet Loopback Plug	$25
760 feet Thin Ethernet Cable	$252
EtherShare/PC Software	$500
EtherPrint/PC Software	$500
Total	$8,902

Table 5: EtherSeries Cost per User

Work stations		4	5	6	7
Cumulative Cost	4,152	5,102	6,052	7,002	7,952
Per User Cost	1,384	1,275	1,210	1,167	1,136

EtherSeries Economics

In keeping with our effort to provide network communications costs, a typical installation, as shown in figure 13, will be evaluated at current prices. Available EtherSeries hardware and software that could be used on this system is shown in table 3. The required hardware and software for the eight station setup in figure 13, assuming one station configured as an IBM XT server with shared printers but no electronic mail, is shown in table 4.

The resulting communications cost per user for EtherSeries is therefore $1113. The starting minimum for EtherSeries (two work stations, one configured as a PC server, and 760 feet of pre-wired bus cable) is $3202. Incremental costs as additional work stations are added are shown in table 5.

Not included in the survey is the cost of installing the network cable. This cost will vary widely depending on the specific installation. It is not inconceivable that cable installation costs may be the driving cost factor for particularly difficult and complex configurations.

Summary

EtherSeries has been described in detail to give the reader an insight into an Ethernet-compatible product that is capable of solving a large variety of local communications needs in an organization. There are many factors to consider in planning an EtherSeries system—the exact requirements for a particular installation should be carefully considered, and the almost inevitable need for future growth should be kept in mind. In this regard, EtherSeries is particularly well-placed to take advantage of existing Ethernet-compatible products and systems. The real value of the EtherSeries network will come with the introduction of applications software packages specifically designed to exploit its versatility. The EtherMail package with its Remote Mail interface is an example of a well-designed application that extends the utility of local area networking.

Companies mentioned in this article
1. Bridge Communications, 10401 Bubb Rd., Cupertino, CA 95014. Circle 463 on Reader Service Card.
2. Codenoll Technology Corporation, 1086 N. Broadway, Yonkers, NY 10701. Circle 464 on Reader Service Card.
3. 3Com Corporation, 1390 Shorebird Way, Mountain View, CA 94043. Circle 465 on Reader Service Card.
4. Ungermann-Bass, Inc., 2560 Mission Blvd., Santa Clara, CA 95050. Circle 466 on Reader Service Card.
5. VisiCorp, 2895 Zancher Rd., San Jose, CA 95134. Circle 467 on Reader Service Card.
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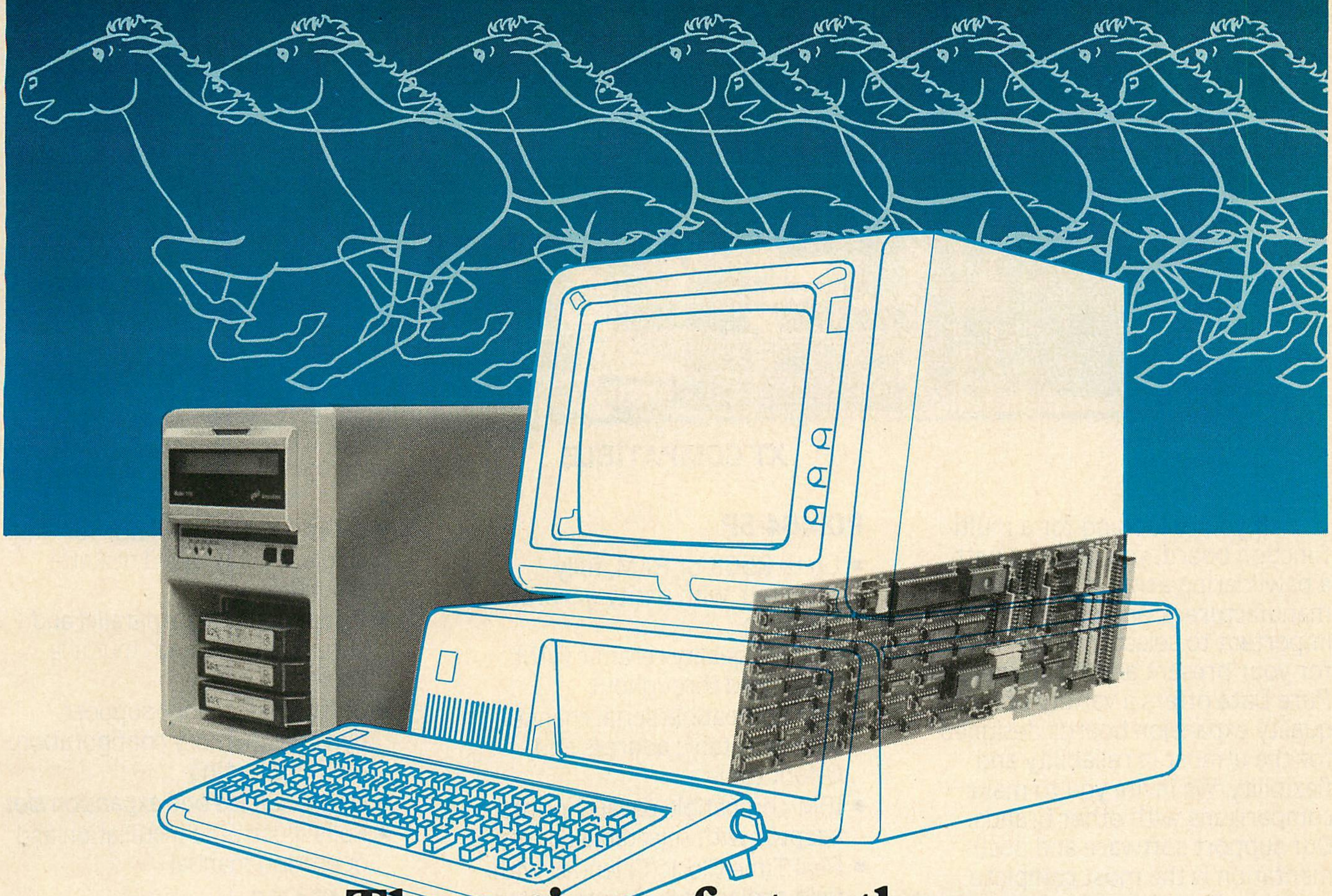

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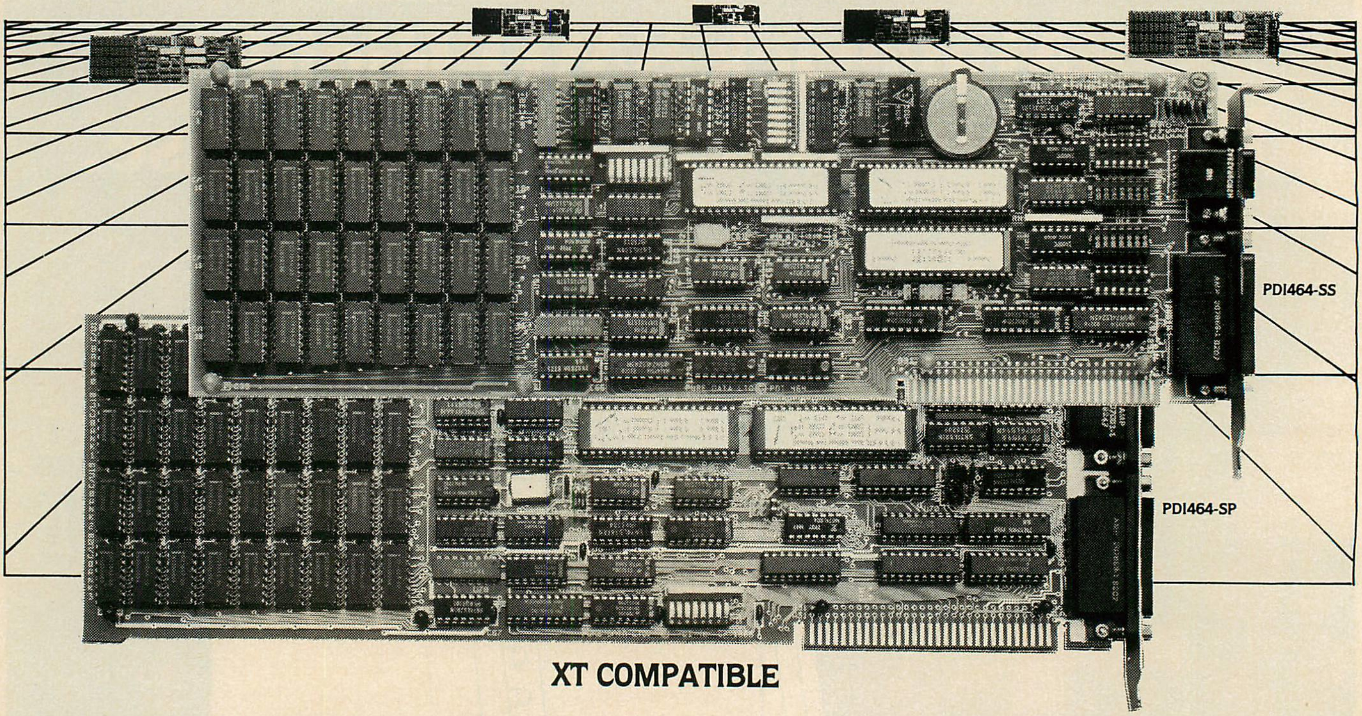

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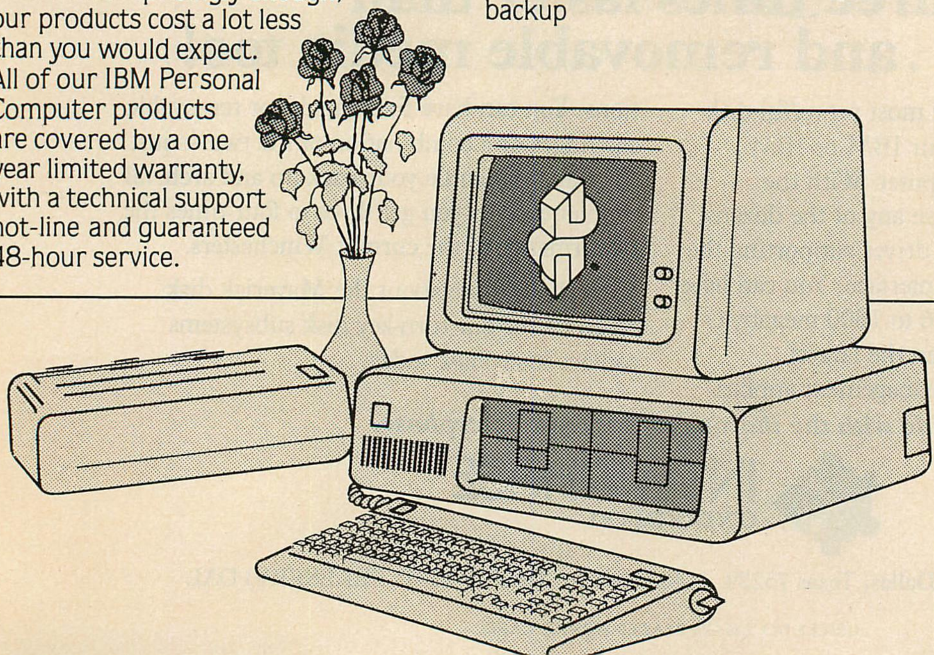

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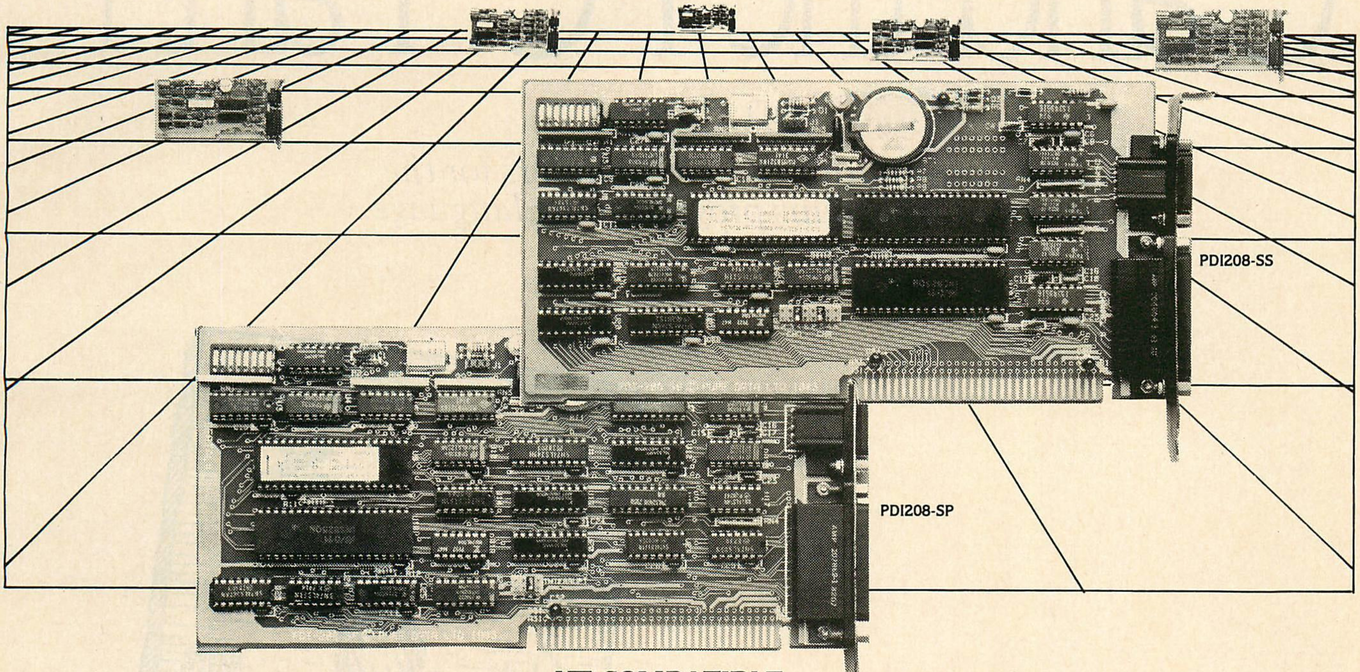

XT COMPATIBLE

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- Print spoolers for parallel and serial channels with multiple copies
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- Fully-illustrated installation and operation manual

PDI208-SS

- Two IBM-compatible serial channels with selectable addresses, 6-foot cables
- Real Time Clock/Calendar with field-replaceable lithium battery backup
- p-Disk™ disk emulator for single/double-sided diskette emulation
- Print spoolers for parallel and serial channels with multiple copies
- Software for clock support, dynamic memory configuration, memory testing
- Only occupies one expansion slot
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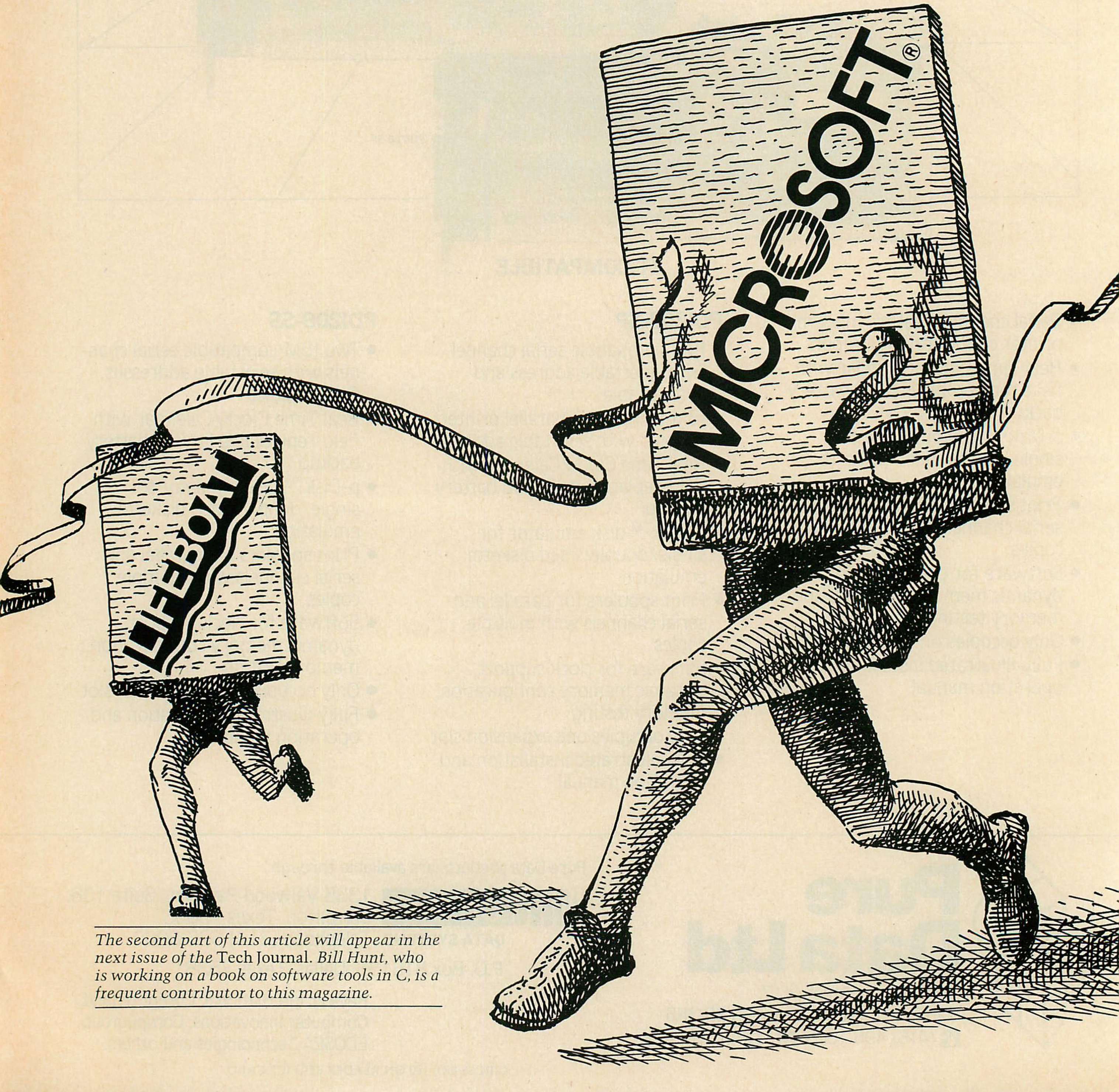
C and the PC: Part 1

BILL HUNT

A close examination of five compilers for the most popular systems programming language.



The second part of this article will appear in the next issue of the Tech Journal. *Bill Hunt, who is working on a book on software tools in C, is a frequent contributor to this magazine.*

In an earlier article, I gave some criteria for choosing a C compiler. This month, using these criteria and a set of performance benchmarks, I will review five compilers.

The compilers reviewed are:

Computer Innovations C86 compiler
Lifeboat Lattice C (Lattice C)
Microsoft C (Lattice C)
Cware C compiler
Manx Aztec C86 (Manx C)

For convenience, I will refer to the Lifeboat, Microsoft and Manx compilers by the shorthand names in parentheses.

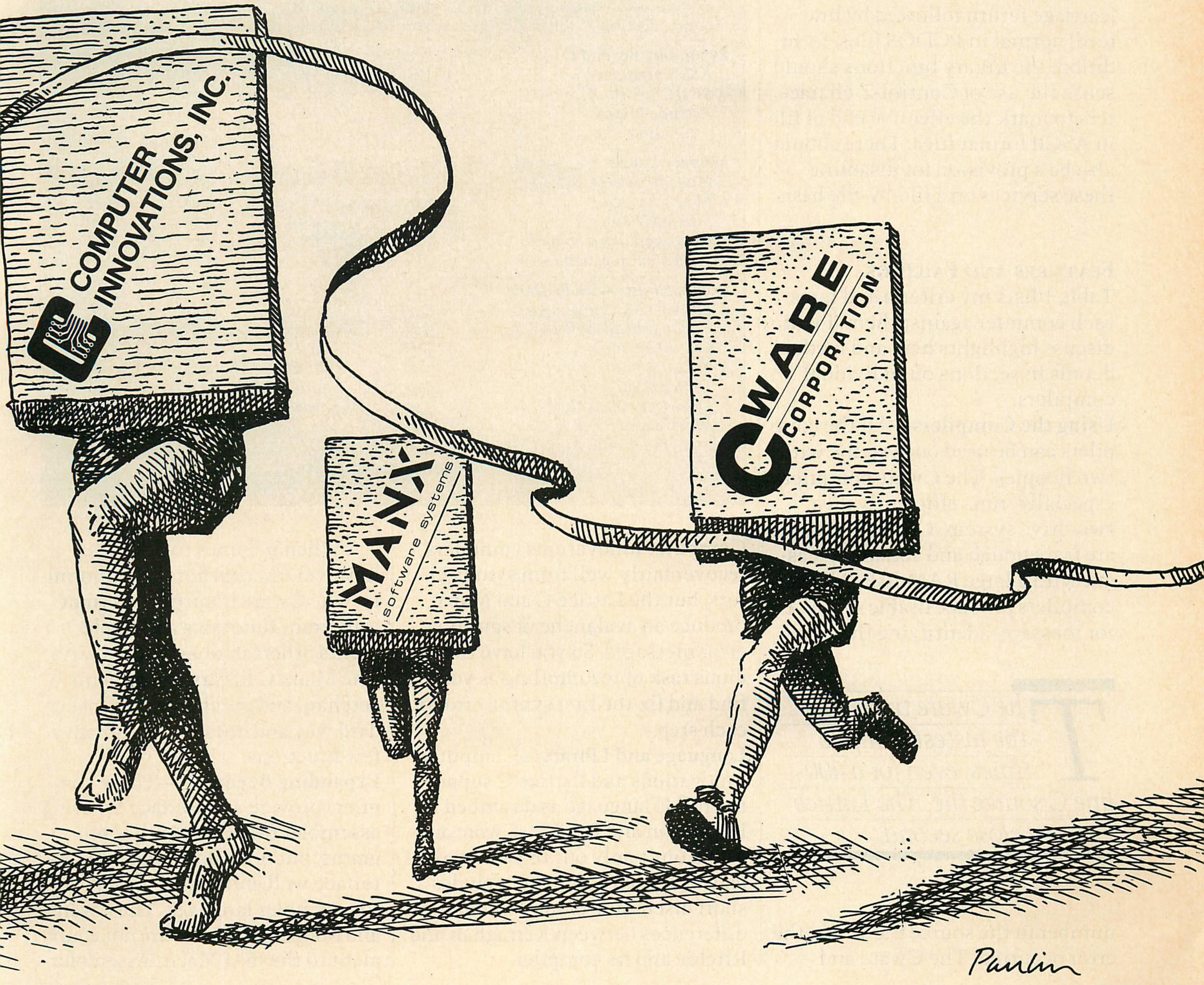
Compiler Criteria

The article "How To Choose a C Compiler" (*PC Tech Journal*, July/Aug 1983) offered the criteria for evaluating C compilers summarized below.

Ease of Use—The compiler should fit comfortably in a floppy-disk-based IBM PC. All files needed for compiling and linking C programs should fit on two 320K floppy disks. Compile and link time should be under a minute for a small program. Syntax errors should be identified with a source file line number so printed listings are not required.

Language and Library support—The compiler should support the full C language, as described in Kernighan and Ritchie, and should also provide a full set of standard library functions. These functions should perform as described in Kernighan and Ritchie and in the Unix Version 7 documentation.

Expanding beyond C—An interface allowing use of assembler functions with C programs should be provided and documented. Functions for access to PCDOS services and to the IBM PC's ROM BIOS services should be provided also. Provision



for excluding library functions to produce compact programs should be included and documented.

Memory Usage—The C compiler should support a maximum size of at least 64K each for programs and data. A larger limit is better but not at the expense of program execution speed. Library functions to access all of the IBM PC's 1 megabyte address space should be provided.

Compatibility with PCDOS—The C I/O library functions should support conversion between the single newline character used as an end-of-line market in many C programs and the two character sequence (carriage return followed by line feed) normal in PCDOS files. In addition, the library functions should sense the use of Control-Z characters to mark the effective end of file in ASCII format files. There should also be a provision for disabling these services on a file-by-file basis.

Table 1: C Compiler Features

	Compiler: Computer Innovations C86	Lattice or Microsoft C	CWARE C	Manx Aztec C86
Price	*$395*	*$500*	*$100*	*$249*
Version Tested	*1.33d*	*1.04*	*1.7*	*1.05i*
Using the Compiler				
Size of Disk Files	*195K*	*220K*	*139K*	*200K*
Fits on 2 Diskettes	*tight*	*tight*	*easy*	*tight*
Compile Speed	*good*	*very good*	*great*	*good*
Syntax Error Messages	*good*	*good*	*good*	*fair*
Language - Full C	*yes*	*yes*	*almost*	*almost*
Standard C Library				
All standard functions provided	*yes*	*yes*	*most*	*yes*
Usage documented	*good*	*good*	*fair*	*fair*
Source Listing	*yes*	*no*	*no*	*yes*
Expanding Beyond C				
ASM Interface	*yes*	*yes*	*yes*	*yes*
PCDOS + BIOS access	*full*	*limited*	*some*	*limited*
Exclude library functions?	*yes*	*yes*	*partial*	*yes*
Memory Usage				
Max program size	*64K*	*64K*	*64K*	*64K*
Max data size	*64K*	*64K*	*64K*	*64K*
Size of C pointers	*16 bits*	*16 bits*	*16 bits*	*16 bits*
Documentation of 8088 segment register usage	*poor*	*good*	*fair*	*fair*
Compatibility with PCDOS				
End-of-Line Conversion?	*good*	*good*	*poor*	*no*
Can it be disabled?	*yes*	*clumsy*	*	—
Ct1-Z sensing?	*yes*	*good*	*fair*	*no*
Can it be disabled?	*yes*	*clumsy*	*no* *	—
DOS 2.0 Support	*not yet*	*not yet*	*no*	*no*
Does I/O re-direction?	*yes*	*yes*	*no*	*yes*
Work with DOS 2.0 re-direction?	*crashes*	*crashes*	*crashes*	*crashes*

(* see text for explanation)

FEATURES AND FAILINGS

Table 1 lists my criteria and rates each compiler against them. I will discuss highlights here and further details in sections on individual compilers.

Using the Compilers—All the compilers can be used on systems with two floppies. The Cware compiler, especially, runs efficiently on a two-drive system. Compile times are fast enough and actually pleasant with a large RAMdisk. All the compilers produce usable syntax error messages identifying the line number in the source file where the error occurred. The Cware and Computer Innovations compilers recover fairly well from syntax errors, but the Lattice C and Manx produce an avalanche of spurious error messages. So you have the tedious task of recompiling as you find and fix the first syntax error of each step.

> *The Cware turned in the fastest compile times, even for a 400-line C source file. The Lattice C was a close second.*

Language and Library—Computer Innovations and Lattice C support the full C language as described in Kernighan and Ritchie. Cware and Manx omit only one or two small C features. Each company includes a short discussion of implementation differences between Kernighan and Ritchie and its compiler.

When it comes to libraries, however, there is not this uniformity. The Cware library omits some important functions and implements others in nonstandard ways. The Manx C library implements getchar() and putchar() in a nonstandard way and does not document a few functions.

Expanding Beyond C—These compilers provide an interface for using assembler functions with C programs, but none documents the interface well enough for readers new to assembler language. The Cware and Manx assemblers are not equivalent to the IBM Macro Assembler.

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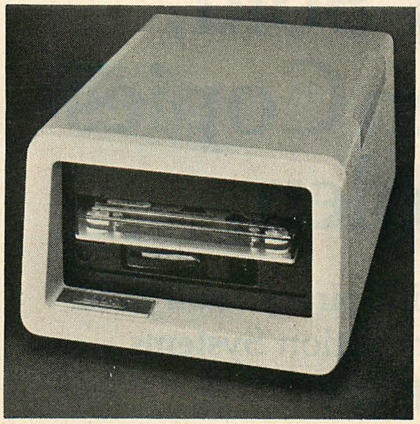

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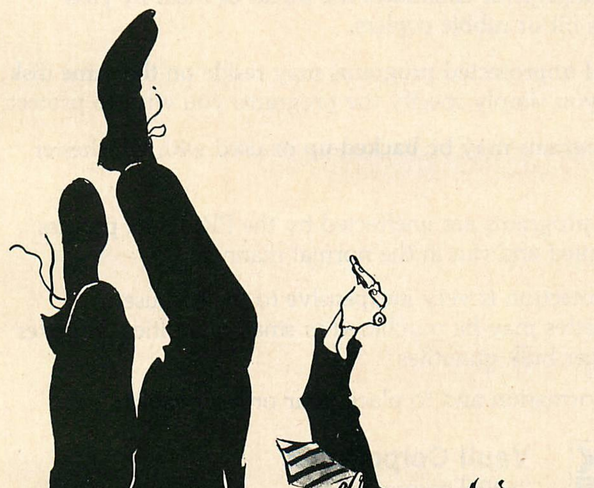


Each product has a mechanism for excluding library functions from programs. None is documented well enough.

The documentation for these assemblers cites an INTEL assembler manual—not an appropriate reference for an IBM PC product.

Without too much trouble, I was able to interface an assembler function with each compiler, although I had to experiment with the non-standard Cware and Manx assemblers to figure out what syntax they accepted.

Each product has a mechanism for excluding library functions from programs. None is documented well enough; Lattice C came closest to being sufficient.

Memory Usage—The same limit—64K each for programs and for data (global and local)—is enforced by each compiler. Computer Innovations and Cware provide library functions that move data anywhere in the PC's 1 megabyte address space.

Compatibility with DOS—Computer Innovations and Lattice C provide options for end-of-line conversion and Control-Z sensing. The Cware and Manx libraries provide no choice—sometimes they do what you want and sometimes they don't.

All of the compilers except Cware support UNIX-style I/O redirection within the compiled program. This is handy if you are using DOS 1.1, but not so handy with DOS 2.0, which intercepts the redirection information on the command line and performs the redirection itself. Unfortunately, when DOS 2.0 redirects standard input to a file, programs produced by all the compilers crash. The source of the problem is within DOS 2.0—faulty implementation of I/O redirection.

The best reason to choose mbp COBOL for your IBM/PC:

GIBSON MIX Benchmark Results
Calculated S-Profile
(Representative COBOL statement mix)

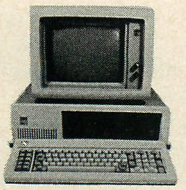
Execution time ratio

mbp COBOL	Level II** COBOL	Microsoft*** COBOL	R-M**** COBOL
1.00	4.08	6.18	8.26

Convincing, isn't it?

The Gibson Mix Benchmark Results chart just about says it all, doesn't it?

Compared with COBOL interpreters, mbp's COBOL Compiler executes programs at least four times faster. With mbp on your IBM/PC,* applications that used to take four hours now take one.



mbp COBOL: 4 times faster.

Why? Because interpreters translate and execute a program one statement at a time, every time the program runs.

By comparison, mbp's COBOL Compiler generates machine language object code, so the entire program is translated only once. It then can be executed as often as you want in a fast single step—with no retranslation.

Develop programs faster.

Bechtel, Chase, Citicorp, Connecticut Mutual, Sikorsky—companies that make their own comparative evaluations—chose mbp. Certainly faster running speed was important to them, but that wasn't the only reason for the choice.

Here's a Connecticut Mutual spokesperson's comment: "...It took us approximately 5% the time to convert (COBOL) programs from the mainframe computer to mbp as it did to convert them to Microsoft's COBOL..."

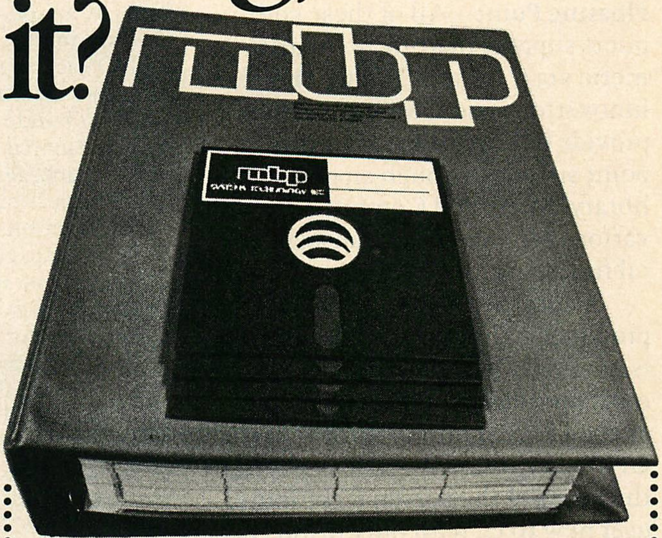
Put another way, mbp saved 95% of the conversion time.

mbp: the complete COBOL.

GSA certified to ANSI '74 Level II; a sophisticated Screen Management System (SMS) and an Interactive Symbolic De-Bug Package included standard; Multi-Keyed ISAM Structure; listing options allow source & object code, map & cross-reference checking; mbp has them all and much more.

After you compare mbp's advantages, compare it's price: $500. Convinced?

128K system with hard disk required. *IBM/PC is an IBM TM; **Level II is a Micro Focus TM; ***A Microsoft TM; ****A Ryan-McFarland TM.



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Nevertheless, compiler vendors should forewarn their customers of this potential difficulty. Actually, most vendors appear to be close to providing DOS 2.0 support for their compilers, so this problem should disappear.

None of these compilers makes use of DOS 2.0 extensions. The compilers do not accept paths as part of file specifications, and the I/O library functions do not allow path names. Only Cware mentions DOS 2.0 in the documentation. Give another low mark to the other vendors.

Unfortunately, when DOS 2.0 redirects standard input to a file, programs produced by all the compilers crash.

Floating Point—All of these compilers support floating point arithmetic via software. The Computer Innovations and Cware compilers provide 8087 hardware floating point support through an optional library. Manx and Computer Innovations provide some transcendental functions as well.

A common failing of these products is that the documentation is not really geared to the needs of most purchasers. While it is often as good as that provided for C in the UNIX environment, it does not fit the needs of the personal computer user new to C, with only BASIC experience as a reference point.

BENCHMARKS—A PENTATHLON FOR C COMPILERS

Listing 1 is a Pentathlon program I developed for comparing C compilers. The program does not perform any useful function or illustrate any interesting techniques, but it does measure the speed of C programs in five different ways. I think of it as a series of track and field events for C compilers—thus the name pentathlon.

The main function prompts for and accepts the number of the benchmark to be run and a number of iterations. It then calls the appropriate function once for each iteration. Timing starts from the entry of the number of iterations and ends when the word *thru* is displayed. Functions bench1 through bench5 contain the details of one benchmark test each. Loops inside these functions execute the code to be tested much more often than initialization steps or the main function's steps would.

Bench1 measures the speed of floating point addition and multiplication. Although some of the compilers support the use of the 8087 floating point processor, I was only able to test with floating point provided by software.

Bench2 measures the speed of calling a C function. The function called executed one operation before returning. This allows us to measure the speed of calling functions, with some protection against a clever compiler's ability to optimize away a function that does nothing. C provides excellent support for a modular programming style with lots of small functions. An efficient implementation of function calling is crucial if this programming style is to be feasible. This test is probably the most im-

C-Food Smorgasbord

Lifeboat markets a package called C-Food Smorgasbord containing functions for use with Lattice C. The package includes decimal arithmetic functions, functions to give access to services in the IBM PC's ROM BIOS, PCDOS access functions, such as file directory reading and a set of functions for building full screen CRT-terminal-oriented applications. The C-FOOD package costs $150.

The decimal floating point arithmetic functions may be worth the price of the package if you are writing an application where dollars and cents arithmetic is needed. Rounding and truncation work as you would expect with decimal arithmetic: This capability could make C more suitable for accounting and other data processing applications. Trying to duplicate these functions yourself would be a unattractive alternative.

The ROM BIOS access functions provide access to some services in the IBM PC's ROM BIOS. The documentation should provide references to the appropriate parts of the IBM PC Technical Reference Manual. A programmer with C and assembler experience could duplicate these functions fairly quickly. If you don't have the experience, you may find these functions useful enough to justify the price.

Some PCDOS access functions, such as file directory access, are also provided, as is a function that allows you to make up your own DOS access function. (You specify register values on input and have access to returned register values.)

The terminal independence functions allow you to write application software for a generic CRT terminal and let the TIP functions convert to handle the specific terminal being used. This is a useful function for computers that are used with a variety of CRT terminals—as the IBM PC has its own built-in and standardized keyboard, the problem doesn't apply. The documentation of the terminal independence package fails to give a reader an overall understanding of how the TIP package works.

The C-Food functions are distributed in the format of a Lattice-C-compatible object library and several header files to be included in the programs you write. A manual describes the major parts of the package and documents each function with a UNIX-style page.

The C-FOOD package works with both the Lifeboat and Microsoft versions of Lattice C. It will not be useful with other compilers such as the Cware, Computer Innovations, and Manx C.

The package will be most useful to C programmers not yet able to write their own assembler functions to perform these functions. It would be more useful to these people if examples of the use of these programs were supplied. It is worth the $150 price if you have a need for decimal arithmetic, otherwise the rest of the package may not be worth $150.

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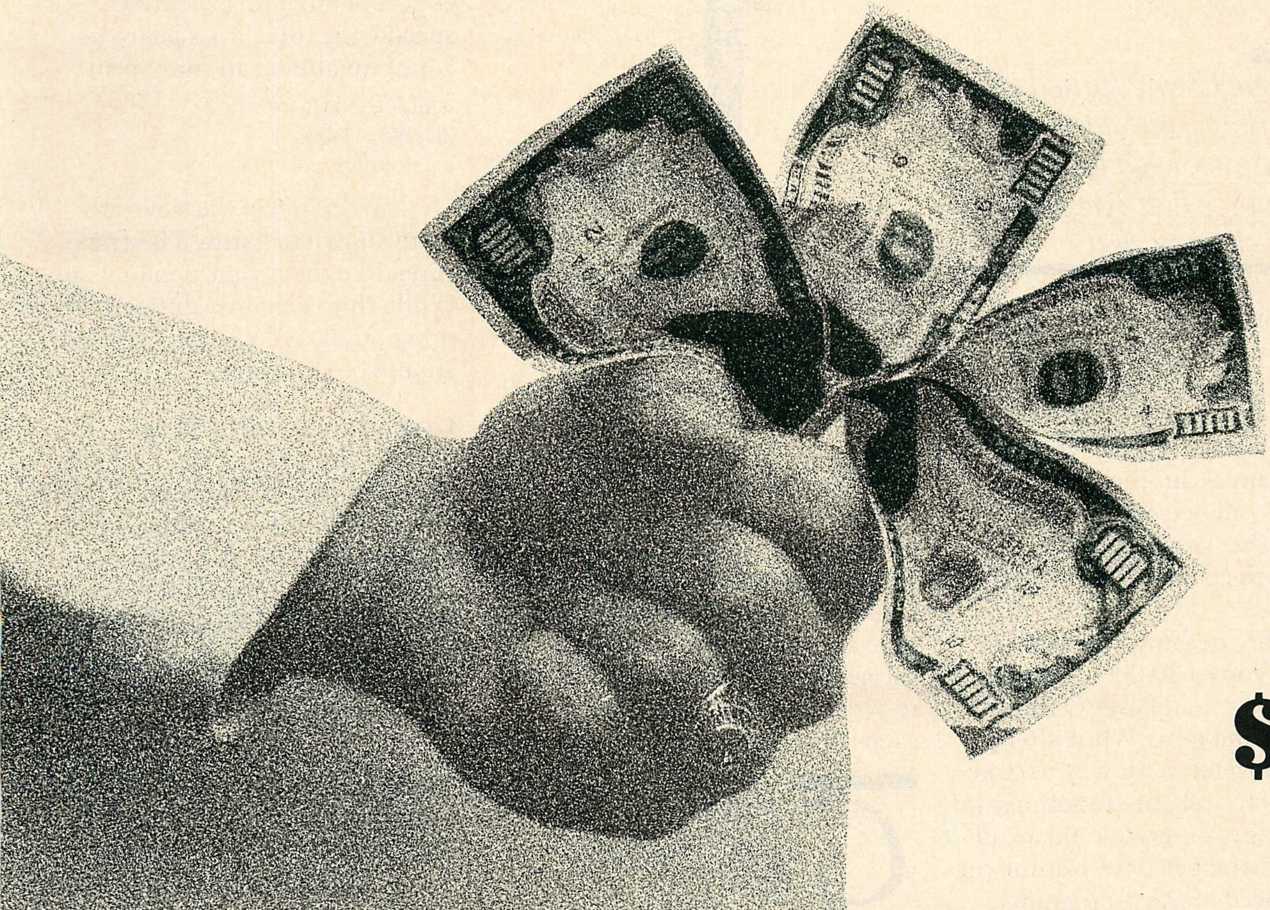

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portant of the five benchmarks.

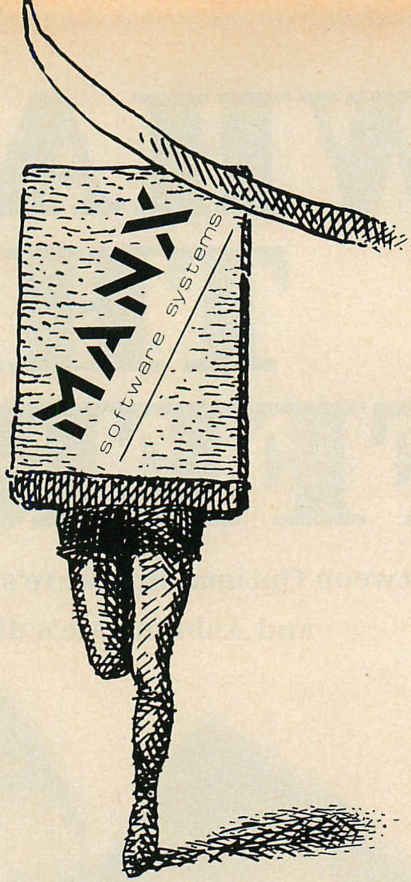
Bench3 measures the speed of a small loop copying a 500-byte character string. The benchmark, written in a compact way, uses pointers with increment operators (+ +) and an assignment in the middle of an expression. Loops like this affect the speed of many C programs. The increment operators and assignments in the middle of expressions allow the programmer to give the compiler clues so that fast, special case code can be generated. In part this test measures how well the compiler takes advice.

The Cware turned in the fastest compile times, even for a 400-line C source file. The Lattice C was a close second.

Bench4 measures the implementation of integer array and character manipulation. It is written in a more normal style than Bench3. I used a register variable in the program as another test of the compiler's advice-taking ability. Such register variables allow the compiler to generate more efficient programs.

Bench5 measures the time required to copy a 30,000-character file using the standard I/O functions getc and putc. While this is not the most efficient way to copy a file, the getc and putc functions are used in many programs and are often the bottleneck determining the overall speed of those programs. Since these functions are supported by most compiler libraries, they allow an apples-to-apples test of file I/O. I ran this benchmark with source and destination files on a single floppy disk. To keep the results comparable, each test was run with the floppy disk empty except for the source file.

Specifying benchmark 6 creates the file that the bench5 uses. I used the Computer Innovations version



of the program to create the file. The file is not very interesting—30,000 *a* characters and a Ctl-Z to mark the end of the file.

File Copying—The 100 Yard Dash

Applications of C often require fast copying of large amounts of data in disk files. Listing 3 shows a program for copying a file using low-level I/O operations. Because the read and write functions shown here are not as well standardized as the getc and putc functions, I had to re-write the program slightly for each compiler. I used a binary or un-

Computer Innovations and Manx C are significantly slower than Lattice or Cware on the function calling, string copy and character count benchmarks.

translated mode wherever possible so that end-of-line conversion and Ctl-Z sensing would not be operating. My intent was not to provide a comparison of execution times for the identical program, but rather to show how well each product could perform fast file I/O.

The same 30,000-character file used in the pentathlon bench5 benchmark is used for this test. (Since the Ctl-Z at the end is treated as data here, the file appears to be 30,001 bytes long.)

The Sieve Benchmark Program

Because the prime number sieve program has become a standard in compiler evaluations I have included it here. It is actually a very limited test of program execution speed—the three lines below account for almost all time spent:

```
while ( k <= size )
(flags[k] = false ;
k + = prime ; )
```

My version of the sieve program shown in listing 3 is structured like the pentathlon program. While this is slightly different from other published versions, results should be the same.

Compile and Link Times

The pentathlon and sieve programs provide a test of compile and link times, as well as execution times. Sieve is about 60 lines long—typical for my C source files. Pentathlon, at about 150 lines, is as large as any C source file I produce. To cover all possibilities, I also compiled a 400-line program.

Times for linking are also reported. For this test I split the Pentathlon program into six source files, because linking six separate files is more usual than linking just one file.

Program Sizes

I have included the sizes of the sieve and benchmark programs for comparison. The differences are not very significant or meaningful. The program sizes are mostly determined by the number of library functions included. (All the compilers provide mechanisms for avoiding inclusion of unneeded library functions.)

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Books About C

None of the C compiler products that I have seen includes tutorial material about C, or provides a full definition of C. You will need help to get started, and a few of the books on C that are starting to appear can really help you. Here are some impressions:

The C Programming Language, Kernighan and Ritchie, (Prentice-Hall).

This is the de facto standard for the C programming language. If you are going to use C you need a copy of this book for reference. You may find parts of it hard going but it is valuable as a reference on C. Buy it and supplement it with one of the other books. Some of the compilers reviewed in the accompanying article include a copy of this book.

C Notes, C.T. Zahn, (Yourdon Press).

This book is similar to Kernighan and Ritchie but easier to use as a reference book. It explains C syntax and topics such as data type conversion in more detail than K&R but it assumes the reader has a computer science background and vocabulary. I used this book as a reference for a while, but no longer find much use for it. As Kernighan and Ritchie is the accepted definition of C, this book will not be necessary for most readers.

The C Primer, L. Hancock and M. Krieger, (Byte Books, McGraw-Hill).

This is a good primer on C. It makes few assumptions about the reader's prior experience with computers. The authors understand C well and have done a good job of capturing that understanding. The first two chapters and chapter 8 on the C preprocessor are the best parts of the book. Chapters 3-12 cover C, with chapters devoted to single aspects, such as control structures. Sometimes dull, these chapters do give solid explanations with proper attention to motivation.

The book does not provide a full education on C. Difficult topics such as file I/O and operating system interfaces are not covered, leaving the reader less than fully prepared for the kind of applications for which C is intended. That qualification made, I can say that this book is successful as a basic primer on C.

C Programming Guide, J. Purdum (Que Corporation).

This book covers C topics more completely than the Hancock book but is not as well written. It is oriented more to the personal computer world. It captures the virtues of C and its underlying concepts. Good features are:

—Functions are discussed early in the book. Functions are the essence of C; the book reflects this.
—Pointers and the C concept of l values are explained thoroughly. Pointers are treated as a normal part of C, to be mastered with the rest of C. In some books, the author treats pointers as a subject the reader should be afraid of.
—Mixing data types and type conversion are covered as a significant topic.
—File I/O is covered fully in 30 pages. File I/O is an important topic even for C beginners.
—An entire chapter is devoted to common mistakes and debugging. The author's practical experience with C and understanding of its concepts are apparent here and in other chapters.

The book does have weaknesses. The C Primer has a better flow and is more fun to read. Examples in Purdum's book are not chosen or introduced as well. The physical book itself is disappointing: Bold face and large type are over-used and, parts of the book seem slightly smudged or fuzzy.

Learning to Program in C, T. Plum (Plum Hall, Inc).

This book appears to have grown out of seminars on C given by the author. Unix version 7 is the environment assumed by the book. One chapter of the book discusses the software development process using a blackjack program as an example (a poor choice). The book is oriented toward programmers and engineers who will be using C in their jobs.

No attention is paid to file I/O or how C interfaces with an operating system. The author mixes facts with advice on conventions and style, without distinguishing them. Syntax diagrams and technical terms (expression trees and argument frame, for example) are used where a simple explanation would do. On the other hand there are good points:

—The way that data is actually represented in memory is discussed throughout the book. Discussions of computer architecture and program structure are used to give the reader an idea of what goes on in a computer.
—An appendix contains a one-page list of common bugs in C programs. The format could be better; explanation should accompany each item on the list.
—Individual topics are discussed in one or two page sections with good illustrations. These topics are chosen with an eye to the differences between C or other languages and the problems that a programmer new to C will have.
—The author is conscientious about tackling the hard and messy parts of C as well as the easy and elegant parts.

The book will be most useful for programmers using C in a Unix environment. Its discussion of the software development process and its suggestion of style conventions has value for people using C in their jobs.

The C Puzzle Book, A. Feier, Prentice-Hall.

This book features a number of examples of tricky and obscure uses of C's features. The reader is supposed to learn to use C by deciphering these examples. I see no point to this book. You can use C for years in a simple and straightforward way without ever worrying about most of the material in this book.

None of these books uses the IBM PC environment as the basis for concrete examples. Some examples may have to be modified before they will work with a compiler on the IBM PC. The Lattice C compiler and the Computer Innovations compiler are two that will cause few problems.

Buying one or more of these books is a must. If you are not an experienced programmer, you should get K&R and one other book.

Procedure and Disclaimer
I timed these benchmarks using a cheap stopwatch and manual timing. Pressing return after typing the number of iterations for the test was the start of the test. The appearance of the word *thru* on the screen marked the end of each test. I adjusted the number of iterations to keep each test between 20 seconds and 3 minutes. The results are reported for a convenient number of iterations. Differences of 2 seconds or more are probably valid.

I used DOS 2.0 for all tests, which, except for the floppy-based compile tests, were run on a 512K IBM PC XT with 12 I/O buffers specified in the config.sys file. I made some efforts to flush the DOS buffers before each test, but in some cases, results were dependent on the number of buffers specified.

Results of the Benchmarks
Table 2 shows the results of our track and field competition. Let's examine event-by-event results.
Compile times - Two figures are reported for each compiler: one with all files on a ramdisk, one with all files on floppies. Times for a hard-disk-based system, or with files split between a ramdisk and floppies, would fall between these numbers. The Cware compiler wins this event with fast compilation even for a 400-line C source file. The Lattice C compiler is a close second, with the Computer Innovations compiler and the Manx Aztec C compiler coming in 10 to 20 seconds slower. But all the compilers are fast enough to be pleasant to use. The key to happiness, whatever the compiler, is having a large ramdisk.

Table 2: C Compiler Benchmark Results

Bench Mark		Computer Innovations C86	Lattice or Microsoft C	CWARE C	Manx Aztec C
Compile Times					
Sieve - 60 lines		18-37 sec	6-25 sec	5-24 sec	15-32 sec
Pentath. - 150 lines		48-73 sec	22-56 sec	13-37 sec	39-62 sec
Big file - 400 lines		105-132 sec	39-98 sec	18-54 sec	81-113 sec
Link Times					
Sieve - 1 file		23-39 sec	13-55 sec	6-34 sec	16-53 sec
Pentathlon - 6 files		25-41 sec	16-42 sec	7-40 sec	19-59 sec
Pentathlon					
Floating Point	*10 iter.*	33 sec	48 sec	27 sec	41 sec
Function Calls	*10 iter.*	18 sec	13 sec	12 sec	21 sec
String Copy	*10 iter.*	31 sec	19 sec	21 sec	26 sec
Char Count	*10 iter.*	23 sec	16 sec	17 sec	16 sec
File Copy (getc/putc)	*2 iter. 30,000 bytes*	146 sec	48 sec	52 sec	42 sec
100 Yard Dash					
File Copy (1 iteration) (read/write) 30,001 bytes					
512 bytes per read		37 sec	14 sec	14 sec	15 sec
1024 bytes per read		32 sec	19 sec	20 sec	9 sec
8192 bytes per read		28 sec	27 sec	27 sec	5 sec
to/from ramdisk		23 sec	3 sec	3 sec	1 sec
Prime Number Sieve (10 iterations)		19 sec	11 sec	12 sec	18 sec
Program sizes (in bytes)					
Sieve		16,438	13,824	8,192	13,120
Pentathlon		17,640	15,360	13,824	14,688

Link Times - Numbers for floppy disk and ramdisk-based systems are shown for each compiler. The linker supplied with the Cware compiler is clearly fastest. Figures reported for Manx C are for the linker pro-

A strength of the Computer Innovations C86 is its full set of 8086 and PCDOS-specific functions.

vided with the compiler. The PCDOS linker can also be used with MANX C, yielding link times close to those of Lattice C, which uses the PCDOS linker.
The Pentathlon - Lattice C and Cware programs are almost equally fast for all but the floating point benchmark. There Cware beats the competition, and Lattice brings up the rear.

Computer Innovations and Manx C are significantly slower than Lattice or Cware on the function calling, string copy and character count benchmarks. The Manx C compiler is the winner in the file copy event, while the Computer Innovations complier is miles behind.
The 100-Yard Dash- Manx C is the winner here by a wide margin: It makes good use of PCDOS's I/O facilities while the others provide only so-so implementation. Lattice and Cware are adequate, but become slower as larger blocks of data have to be transferred. This seems backwards—larger transfers should be faster. The results are reproducible, and the same behavior holds in DOS 1.1 environment.

The Cware library does not allow you to make an exact copy of the original program. It pads the file to make it a multiple of 128 bytes in length—sometimes this is all right, sometimes it's a disaster.

The Computer Innovations compiler lags in the rear for this test. It is slower than the others by a

factor of 10 for I/O to and from a ramdisk.

Sieve Program - Lattice C and Cware are neck and neck here, with Computer Innovations and Manx C significantly slower.

Evaluations

Computer Innovations C86

The compiler handles syntax errors fairly well. Each error encountered results in one or two error messages that identify the line number in the source file where the error was. A single compilation usually identifies all syntax errors in a C source file.

Compilation speed and the execution speed of the resulting programs is adequate for most purposes, but not as good as for the Lattice C product or the Cware compiler. The biggest plus for the CI-C86 compiler is that complete source is provided for the standard library and for run-time support functions. An excellent way to learn how I/O functions really work, this provides examples of C functions. As you gain more experience with C you can make modifications to the library functions.

The compiler produces object code in a format unique to this product. A special linker is provided to accept this format. Assembler functions assembled by the IBM Macro Assembler can be converted to this object module format by a conversion program supplied with the package. This allows assembler functions to be combined with C functions.

Another strength of this product is its full set of 8086 and PCDOS-specific functions. You can immediately begin to make full use of the PC's cabablities without knowing all the details of its architecture or how to write assembler functions.

The documentation is quite good at getting you started in using the compiler and in describing available options for the compiler,

the linker and for other programs in the package. The standard library functions, and those library functions specific to this implementation, are also well-described. File I/O implementation, the interface to assembler functions, memory usage of compiled programs, and usage of the 8088 segment registers are not fully documented. The reader is often referred to the library function source files in lieu of an explanation. This is better than nothing, but isn't adequate.

> *Buffered outputs is an unfortunate design choice for Lattice C.*

The most serious disadvantage of this product is the slow speed of the standard library I/O functions. Because they are slower than those provided by BASIC, the natural advantage of C is lost for many applications. An experienced C programmer can modify the library functions but a newcomer to C will probably just have to suffer with the problem awhile.

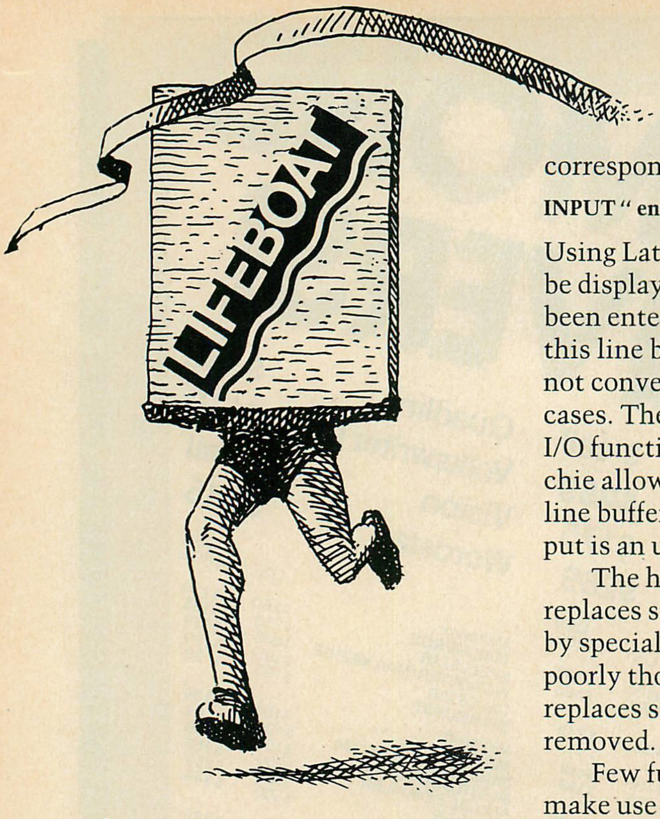
A CP/M-86 version of the compiler is also available.

In summary, the C86 compiler is a well-thought-out product with everything you need to write useful applications on the PC. Its main shortcomings are meager documentation of a few topics and sloppy implementation of some library functions.

Lattice C

This compiler is a fine all-around product. It implements the full C language and the standard I/O library. Compilation is fast, and the compiled programs tied for first in the pentathlon.

The Lattice C manual covers the necessary subjects thoroughly. Some of the discussions are long-winded, with sleep-inducing paragraphs, but the information you need is there. Examples are provided in some places but not all.



The example used to illustrate the interface to assembler language functions is poorly chosen—it is too complex and the context in which it is called is not shown.

One topic covered in this manual is how to use a different startup function to exclude library I/O functions. Three sample startup functions are provided as C source files. A header file, conio.h, that replaces the standard I/O functions is also provided. Using the tinymain.c function and conio.h reduced the sieve program by about 6000 bytes.

The library provides a "translated" mode for file I/O with recognition of the Control-Z end-of-file marker and conversion between the PCDOS and C end-of-line markers. The method for overriding these services is rather clumsy, but is documented.

One very annoying feature of the standard I/O library implementation is that output to the console is buffered until a newline character is output. Buffering lines of output to the screen is necessary on time-shared mini-computers but is a pure annoyance on a personal computer. For example, the C fragment below

```
printf ("\n enter number");
scanf ("%d",&n);
```

corresponds to the BASIC

```
INPUT " enter number";n
```

Using Lattice C the prompt would be displayed after the number had been entered. A kludge to defeat this line buffering is provided but is not convenient or applicable in all cases. The definition of standard I/O functions in Kernighan and Ritchie allows either unbuffered or line buffered output. Buffered output is an unfortunate design choice.

The header file conio.h, which replaces standard input and output by special unbuffered versions, is poorly thought out. The part that replaces stdin functions should be removed.

Few functions are provided to make use of PC's hardware or of the PCDOS operating system features. Some of these functions are provided in the $150 C-Food Smorgasbord, but the basics should be in the compiler product. For example, these functions would have been appreciated:

Block move - to move blocks of data between any two areas of memory (anywhere in the PC's 1 megabyte address range).
PCDOS access - to provide access to any of the operating system's services. The single BDOS function provided is limited to those services requiring only AX and DX register inputs. This limits you to a few of the simplest DOS functions.
ROM BIOS Access - to give access to the PC's ROM BIOS services.

The compiler does not recover well from syntax errors. Only the first error message is reliable. This is out of character with a generally high-quality product.

Lifeboat and Microsoft Versions of Lattice C

I compared the object modules from the Lifeboat and Microsoft compilers and found them to be identical. Spokesmen for Lifeboat ad Microsoft verified that both products incorporate the same Lattice C compiler. Consequently, you get to choose between two ways of buying this compiler. Either way you get a product maintained and enhanced by Lattice, Inc. Lifeboat and Microsoft are the first level of support; in both cases the developer is the final source of technical support.

> *Both the Lifeboat and Microsoft compilers incorporate the same Lattice C compiler.*

A CP/M-86 version of the Lattice C compiler is available from Lifeboat only.

The Microsoft compiler product includes a library manager and the MS-DOS linker. At present the Lifeboat version does not include a comparable library manager.

The library manager is quite userful for building a library of functions that you have written. The program is quite general and can be used with other object module files accepted by the MS-DOS linker. It could, for example, be used with object modules produced by the IBM Pascal compiler or the IBM Macro assembler.

The Microsoft product also includes a version of the MS-DOS linker compatible with DOS 1.0, 1.1, or 2.0. Because PC-DOS includes the linker, the MS-DOS linker does not offer any benefit to IBM PC users. A linker reference manual not provided with PC-DOS does give some extra information on how the linker works.

C-Ware

The Cware compiler is a mixture of good news and bad news. The compiler compiles programs quickly and the programs execute quickly, too. The full C language is supported and 8087 support is provided. The package includes a full screen editor, an assembler, a linker, and a library manager, in addition to the compiler. While the assembler is

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not adequate for large assembler projects or for device drivers, it is okay for writing assembler functions for use with C programs.

The documentation is quite good in some areas (getting started, command syntax, and options); skimpy in others (standard library functions, assembler language interface, and the execution environment). It assumes that the reader is an experienced programmer familiar with C and can cope with the differences between this implementation and that required by examples in books about C.

Not all the standard C library functions are present; a few that are, such as fopen() and gets (), work in non-standard ways. Before I could compile the pentathlon program, I had to add these lines to stdio.h:

```
#define stdin 0
#define stdout 1
#define stderr 2
#define fclose (a)    close (a)
```

The compiler supports the full C language with one exception. It does not recognize the preprocessror statment

```
#includ ⟨filename.ext⟩
```

Instead, it recognizes the form with filename.ext. Because such statements occur in a large number of C programs, this is a significant annoyance.

Conversion of end-of-line markers is performed by some functions and not by others. The results are bizarre—scanf works normally, but getchar () and getc () are abnormal. In addition, getchar () does not treat Ctl-Z as marking the end-of-file, while getc (stdin) does.

The file I/O functions attempt to handle Control-Z sensing automatically without any provision for defeating this service. So you cannot read and write some files as you choose. If you need to read files created by canned software or to produce files for input to such programs, the Cware product will give you unnecessary headaches.

If you need to read files created by canned software or to produce files for input to such programs, the Cware product will give you unnecessary headaches.

With this compiler, running C programs from Kernighan and Ritchie, or one of the other books on C, would be frustrating. This compiler is priced to appeal to newcomers to C whose experience is limited to BASIC. These buyers would have been better served if Cware had followed the standard library closely.

A CP/M-86 version of the compiler is available from Cware.

While this compiler is a good buy at $100, it could have been a world beater with a little more effort. A new release seems to have fixed many of the problems that I found. I will report on the its progress next month.

Manx C

The Manx C package includes an assembler, a linker, and a library manager. The compiler produces assembler source code with an option selecting the Manx Assembler format or the IBM Macro Assembler format. I verified that both options produced valid programs. Because the Manx assembler and the Manx loader used with it are smaller and faster than their IBM counterparts, I used them for the compile and link time tests.

Source code is provided for the library functions. This is a big plus for the Manx. It is good learning material and allows you to tailor things to your liking.

File I/O is this compiler's strong suit—the functions are fast, faster than those of the other compilers. The negative side: There are no end-of-line conversion facilities. Manx C is fine for writing your own programs but not so good for running standard C programs.

The Manx C compiler generates assembler source files as its output. Using the Manx assembler makes this bearable if not pleasant.

The Manx C compiler is quite new—at least in its IBM PC version—and the documentation reflects this newness. Poorly printed, the manual is missing a few important topics.

Syntax errors produce reasonable error messages with an identifying line number. Unfortunately, the compiler then produces a nearly infinite number of spurious error messages. It is easily the worst of the group in this regard.

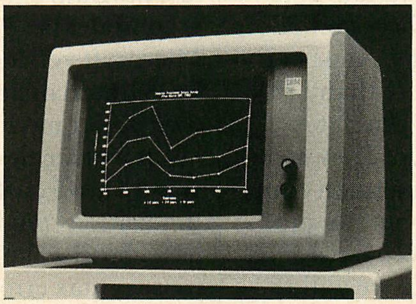
The compiler does not seem to check for errors in writing its output. When I ran out of room on a disk, the compiler continued merrily dropping its output in the bit bucket. The assember program that uses its output then produced a number of irrelevant error messages. This is a really dumb bug and should be fixed immediately. Check before you buy the product.

Versions of the Manx C compiler for CP/M-86, CP/M (8080) and the Apple (6502) are available from Manx.

Fitting the Buyer's Needs

The compilers reviewed are aimed at experienced programmers who want a good tool for personal use. All are effective tools and pleasant to use. The Computer Innovations and Lattice C compilers are the most useful products; if money is a major factor, the Cware compiler is a good buy.

None of the available C compilers fits the needs of newcomers to C well, requiring too high a level of knowledge from the user. The Computer Innovations and Lattice C compilers come closest, but at $400 to $500, may be too expensive for many buyers. If you are a newcomer to C, expect frustrations and wasted effort in getting started. Persevere and you will find C to be worth the effort.



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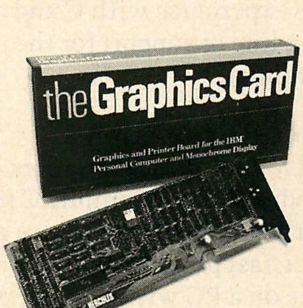

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For developing a serious software product, all of these compilers have some limitations. None of the four makes use of more than 128K of memory and none generates highly optimized code. They are suitable for developing small or medium-sized products but not products that strain the resources of an IBM PC. Next month, we will review a group of compilers that meet these needs, and report on enhancements to the products reviewed here.

Where to purchase a compiler

C compilers are too exotic to be stocked by most retail computer or software stores. It is also unlikely that such stores will have any expertise with the C language. While retailers may be willing to order a C compiler for you, they probably cannot offer succor and support once you've got it. So where do you buy a compiler?

You will probably have to order the compiler by mail—either from the vendor or a mail-order firm. The Computer Innovations compiler and both versions of the Lattice C compiler are being advertised by discount mail-order firms at prices up to $100 off the list price.

The Computer Innovations compiler is also available through Vandata. It provides a file transfer program, Vamp, as a bonus. This program supports the Modem7 checksumed protocol used by many CP/M and IBM PC file transfer programs and bulletin boards. Vandata has experience with C and offers a first line of support for the compiler.

Recommendations

All four of these compilers are good products. They compile C programs fairly quickly and produce compact, fast programs. All are quite usable on a PC with two floppies and 128K of RAM (192K for DOS 2.0). Compared to Microsoft Pascal or Fortran they seem like perfection.

If you can spend $500 and value fast program execution the Lattice C compiler is a good choice. The Microsoft version includes the MS-DOS librarian needed to build your own object module libraries.

If you are new to C and can stand a $395 outlay, the Computer Innovations product might be the best choice. The compiler handles most syntax errors well, and the library functions work in a sensible way. Reading the source files for the library functions can help you to understand C, as well as the library functions themselves.

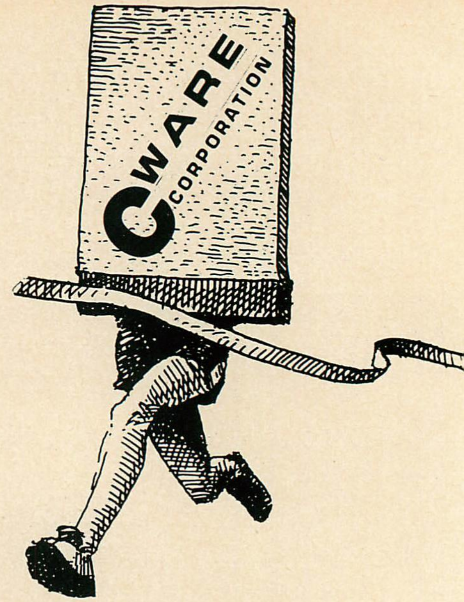
If a $100 price seems bearable but $400 does not, the Cware compiler is a sound buy. The fundamentals are great, and perhaps you can tolerate some warts for a $300 saving. Check it out to see how the wart removal process is going before you decide on a compiler.

The Manx C compiler will also do the job. It is not as fast as Lattice C or Cware and lacks the polish of the Computer Innovations and Lattice C compilers. The $249 price makes it a possbile alternative to the Cware compiler. Improvements in speed and polish would make it more competitive.

C compilers are too exotic to be stocked by most retail computer or software stores. You will probably have to order one by mail.

I have commented on shortcomings in these compilers not only to inform the buyer but also to spur the vendors to improve their products. I hope that they will rapidly make my negative criticisms obsolete. Before you buy, contact the vendors to ask if problems have been fixed.

Next month, we will review several more C compilers, give an update on the compilers reviewed here, and offer some overall recommendations.



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206-828-8080
CIRCLE 457 ON READER SERVICE CARD

AZTEC C86
$249
Manx Software Systems
Box 55
Shrewsbury, NJ 07701
201-780-4004
CIRCLE 458 ON READER SERVICE CARD

CI-C86
$389
Vandata
1744 Midvale Ave. North, Suite 107
Seattle, WA 98133
206-542-7611
(includes VaMP file transfer program)
CIRCLE 459 ON READER SERVICE CARD

LISTING 1 PENTATHLON PROGRAM

```
/*      Pentathlon program      */


#include "stdio.h"

main()
 {
   int i , niter ;
   int ibench ;

   printf("\n benchmark:\n");
   scanf("%d",&ibench) ;

   printf("\n no. iterations:\n");
   scanf("%d",&niter);

   for( i=1 ; i <= niter ; i=i+1 )
      {
        switch( ibench )
          {
          case 1 : bench1() ; break ;
          case 2 : bench2() ; break ;
          case 3 : bench3() ; break ;
          case 4 : bench4() ; break ;
          case 5 : bench5() ; break ;
          case 6 : makefile() ; break ;
          } ;
      } ;
   printf("\n thru\n");
 }


int bench1()      /* floating point arithmetic benchmark */
 {
   int i , j ;
   float x[100] , y[100] , z ;

   for( i=0 ; i < 100 ; i=i+1 )
      { x[i] = i+1 ;
        y[i] = 3*i ;
      } ;

   z=0 ;
   for( j=0 ; j < 10 ; j=j+1 )
      {
        for( i=0 ; i < 100 ; i=i+1 )
           { z = z + x[i]*y[i] ; } ;
      }
 }


int bench2()            /* function calling benchmark */
 {
   int i ;

   for( i=0 ; i < 20000 ; i=i+1 )
      { dummy(i) ; } ;
 }

int dummy(i)
 int i ;
 {
   return( i+1 ) ;
 }


int bench3()      /* string copy benchmark */
 {
   int i ;
   char s[501] , s2[501] ;

   for(i=0 ; i < 500 ; i=i+1 )
      { s[i] = 'a' ; } ;
   s[500] = '\0' ;

   for( i=0 ; i < 100 ; i=i+1 )
      { scopy(s2,s) ; } ;
 }


int scopy(to,from)      /* string copy function */
 char *to ;         /* pointer to destination string */
 char *from ;       /* pointer to source string */
 {
   while( (*to++ = *from++) != '\0' ) /* check for end of string */
     { ; } ; /* copy one char and advance ptrs */
 }

int bench4()    /* character count benchmark */
 {
   int i ;
   char s[501] ;
   int cnt[128] ;

   for(i=0 ; i < 500 ; i=i+1 )
      { s[i] = i + 1 ; } ;
   s[500] = '\0' ;
   for( i=0 ; i < 100 ; i=i+1 )
      { count_chars(s,cnt) ; } ;
 }

int count_chars(string,counts)
 char string[] ;
 int counts[] ;
 {
   register int i ;
   register char c ;

   i=0 ;
   c = string[i] ;
   while( c != '\0' )
     { counts[ c & 0x7f ] ++ ;
       i = i + 1 ;
       c = string[i] ;
     } ;
 }


int bench5()     /* file copy with getc/putc */
 {
   FILE  *in ,
         *out ;
   int c ;
   long n ;

   in = fopen("a:test.in","r");
   out = fopen("a:test.out","w");
   if( (in == NULL) || (out ==NULL) )
     { printf("can't open a file");
       exit(0) ;
     }
   n=0;
   c = getc(in) ;
   while( c != EOF )
     { n=n+1 ;
       putc(c,out);
       c = getc(in) ;
     } ;
   printf("\n %ld characters",n);
   fclose(in);
   fclose(out);
 }


int makefile()     /* create test file */
 {
   FILE  *out ;
   long n ;

   out = fopen("a:test.in","w");
   if( out ==NULL )
     { printf("can't open test file");
       exit(0) ;
     }
   n=0;
   for( n=0 ; n < 30000 ; n=n+1 )
     { putc('a',out) ; } ;
   fclose(out);
 }
^Z
```

LISTING 2 FILECOPY PROGRAM

```
/*     Filecopy Program      */

#include "stdio.h"
#define  NO_FILE     (-1)
#define  RD_MODE      0
#define  WR_MODE      1
```

```
main(argc,argv)
 int argc ;
 char *argv[] ;
 {
    int     in ,
            out ;
    int c ;
    long n ;
    char buffer[16384] ;
    int nr ;

    if( argc < 3 )
      { printf("\n no file names \n");
        exit(0);
      }
    printf("\n bytes to read \n");
    scanf("%d",&nr);

    in = open(argv[1],RD_MODE);
    out = creat(argv[2],WR_MODE);
    if( (in == NO_FILE) || (out == NO_FILE) )
      { printf("can't open a file");
        exit(0) ;
      }
    n=0;
    c = read(in,buffer,nr) ;
    while( c > 0 )
      { n=n+c ;
        write(out,buffer,c);
        c = read(in,buffer,nr) ;
      } ;
    printf("\n thru -  %ld chars\n",n);
    close(in);
    close(out);
 }
^Z
```

LISTING 3 PRIME NUMBER SIEVE PROGRAM

```
/*    Prime Number Sieve Program     */


#define true 1
#define false 0
#define size 8190
#define sizepl 8191

#include "stdio.h"

main()
 {
    int i , niter , count ;

    printf("\n no. iterations:\n");
    scanf("%d",&niter);

    for( i=1 ; i <= niter ; i=i+1 )
       { count = sieve() ; } ;

    printf("\n thru - %d primes \n",count);
 }


int sieve()
 {
        int i,prime,k,count;
        char flags[sizepl];
            count=0;
            for(i = 0; i<=size;i++)
                flags[i]=true;
            for(i=0;i <= size; i++){
                if(flags[i]){
                    prime = i+i+3;
                    k=i+prime;
                    while(k<=size){
                        flags[k] = false;
                        k += prime;
                    }
                    count = count+1;
                }
            }
        return(count);
        }
^Z
```

LISTING 4 SOFTWARE INTERFACE ROUTINE

```
;       execute an s/w function call with all registers set up

;       EXAMPLE OF USE
;
;       struct regval{ unsigned ax,bx,cx,dx,si,di,ds,es;};
;       struct regval  input_regs ; /* input register values */
;                      return_regs; /* values returned in regs */
;
;       status = swint(fun_code,&input_regs,&return_regs);


;       structure for register values is
;               struct regval{ unsigned ax,bx,cx,dx,si,di,ds,es;};
regs    struc
reg_ax  dw      0               ; ax value
reg_bx  dw      0               ; bx value
reg_cx  dw      0               ; cx value
reg_dx  dw      0               ; dx value
reg_si  dw      0               ; si value
reg_di  dw      0               ; di value
reg_ds  dw      0               ; ds value
reg_es  dw      0               ; es value
regs    ends

;       define arguments
args    struc
ret_adr dw      0
old_bp  dw      0
int_no  dw      0               ; number of interrupt to issue
sreg    dw      0               ; address of input reg. values
dreg    dw      0               ; store returned reg. values here
args    ends


code    segment byte public
        assume  cs:code
        public  swint

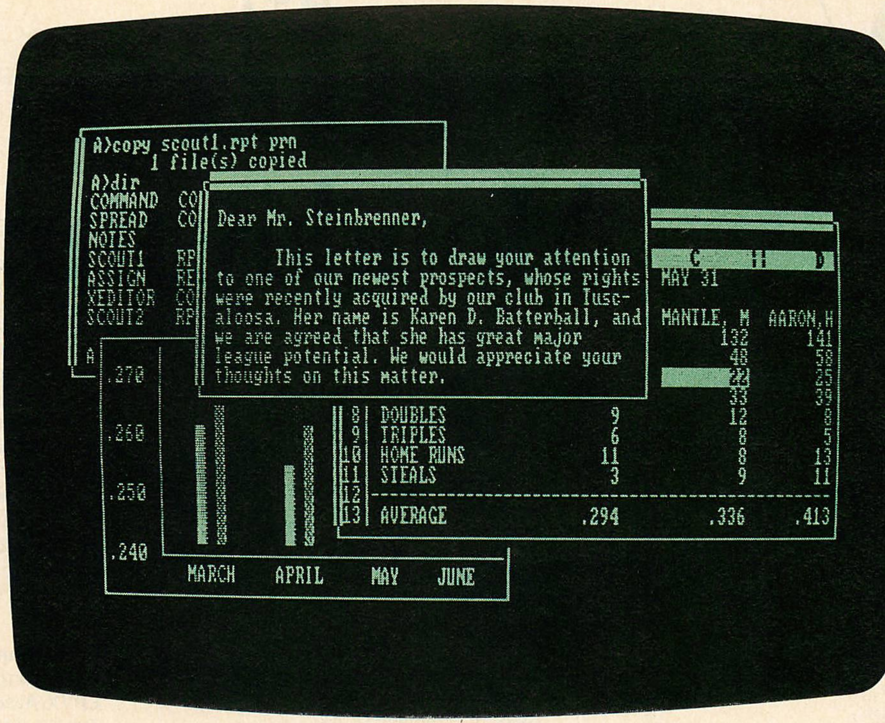
swint:
        push    bp
        mov     bp,sp           ;set our arg pointer
        push    ds              ; save ds as a local variable
        push    es
        mov     al,byte ptr int_no[bp] ; insert int. no into the instruction

        mov     bx,offset int_instr
        mov     byte ptr cs:[bx+1],al
        mov     bx,word ptr sreg[bp] ; set up address of input register values
        mov     ax,word ptr reg_ax[bx] ; place values in registers
        mov     cx,word ptr reg_cx[bx]
        mov     dx,word ptr reg_dx[bx]
        mov     si,word ptr reg_si[bx]
        mov     di,word ptr reg_di[bx]
        mov     es,word ptr reg_es[bx]
        mov     ds,word ptr reg_ds[bx]
        mov     bx,word ptr ss:reg_bx[bx]
int_instr:
        int     00H             ; dummy int. number (filled in on each use)

        mov     bp,word ptr dreg[bp] ; set up address of return register area

        mov     word ptr reg_ax[bp],ax ; store register values there
        mov     word ptr reg_bx[bp],bx ; and store it
        mov     word ptr reg_cx[bp],cx
        mov     word ptr reg_dx[bp],dx
        mov     word ptr reg_si[bp],si
        mov     word ptr reg_di[bp],di
        mov     word ptr reg_ds[bp],cx
        mov     word ptr reg_ds[bp],ds
        mov     word ptr reg_es[bp],es
        pushf                   ; return flags
        pop     ax              ; in ax
        pop     es
        pop     ds              ; restore registers
        pop     bp
        ret

code    ends
        end
^Z
```



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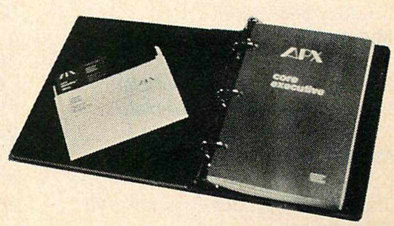

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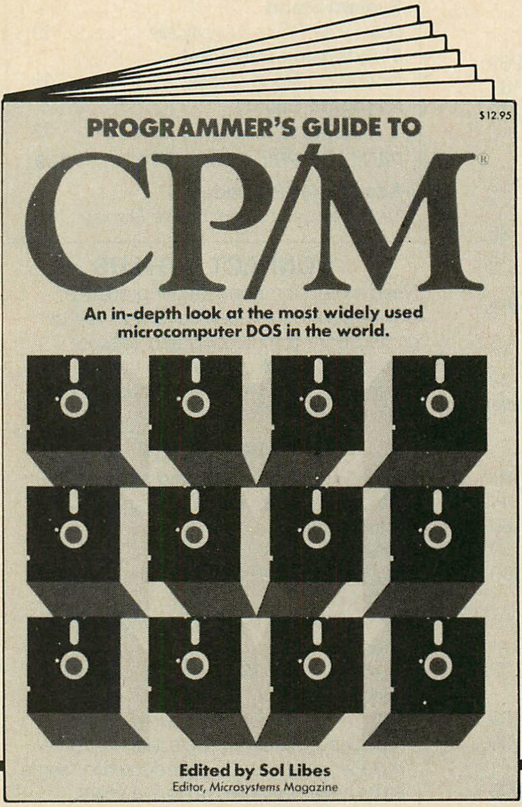

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SOFTWARE REVIEW

APL TWO SYSTEMS: A Comparative Review

An expert looks at two of the big guns in APL.

BOB SMITH

For those in the APL community, having their favorite language on a micro is a dream come true. So when STSC introduced an APL system in January 1983, people got excited. Adding to the excitement was the knowledge that the IBM Madrid Scientific Center had a version for the PC. The competition couldn't help but benefit us APLers. In June the IBM system was announced. Now that two of the heavies in APL have delivered, the time is ripe for a close look at their handiwork. Reviewed here are the IBM Personal Computer APL Version 1.00 (dated May 23, 1983), and STSC's APL*PLUS/PC Application Development System Version 2.6 (dated April 29, 1983).

OPENING THE BOXES

The IBM system comes boxed in the now-standard D-ring binder in a pressboard sleeve. The manual contains about 360 pages divided into 12 chapters, three appendices, and an index. The 12 chapters are split into two parts—an operation guide and an APL reference guide.

The operation guide (150+ pages) introduces the system (backup, startup, the character set, input editor, etc.). It also describes the five application workspaces supplied with the APL system. The PRINT workspace (actually a transfer file) manages the printer; EDIT implements a full screen function editor; FILE manipulates PCDOS files; VM232 communicates with remote computers; MUSIC manages the speaker. The section on VM232 contains 11 pages of uncommented APL code to aid you in transferring data between your PC and a remote IBM VM/CMS.

Chapter 3 in the IBM manual discusses the distributed auxiliary processors (APs), which enable the system to deal with the outside world. The following chapter discusses how to build your own AP by programming in 8088 assembly language.

The second part (170+ pages) concerns the APL language, and describes system commands, function definition mode, and the like.

The three appendices discuss Alt-codes and associated characters, printer control codes, and internal representation of displayed characters (but not the atomic vector).

Stick-ons for the keyboard are provided to help you remember the location of the APL characters.

The STSC system is divided into a programmer's reference manual and two APL texts. One of the APL texts is the well-known Wiley publication, *APL–An Interactive Approach* (known to insiders simply as AIA), by Gilman and Rose. This 378-page book covers the APL language in a breezy style. The other text is an STSC publication, *APL Is Easy*, by Jerry Turner. This 173-page book shepherds novices through their first 10 or 15 hours.

Bob Smith is president of Qualitas, Inc., an IBM PC software vendor. He has 13 years experience in the APL field in everything from programming and marketing to system implementation and language design.

The STSC's programmer reference manual comes in a three-ring binder along with a character generator ROM for your monitor board, the system disk (which includes 14 workspaces of APL code), stick-ons for the key caps, a product registration card, a statement of support policy (they have a hot line, for example), and a 6-by-10-inch plastic card with a picture of the APL keyboard on one side and the Text keyboard on the other. The reference manual weighs in at 420+ pages with six chapters, nine appendices, a glossary, and an index.

The six chapters cover getting started, system commands, language summary, system features, keyboard and editing, and special hints. The appendices are packed with information. One couples a display of the atomic vector with the IBM character ROM (supplied with your monitor board) and the STSC ROM, for easy comparison. Others cover communications transmission code tables, PCDOS and the APL⋆PLUS/PC system, differences between the /PC system and other APL⋆PLUS systems, installing the system software, and more. The 26-page glossary should be helpful to novices. All in all, a hefty package.

Requirements

The IBM system needs a minimum 128K of memory, an 8087 floating-point coprocessor, and a color/graphics board and monitor. It will also use an optional graphics printer, monochrome monitor, and serial port.

The STSC system needs a minimum 128K and a monochrome or color/graphics board and monitor. If you have an 8087 installed, APL⋆PLUS will use it. Otherwise, the system automatically uses software simulation routines for floating-point work. STSC's version will also take advantage of optional printers, monitors, and serial ports.

Starting The Systems

With the STSC system, you must first install the character ROM, the directions for which are buried in Appendix I of the reference manual. There is a pointer to the installation instructions in the ROM's container.

With both systems, you can simply type APL. With the IBM system, first ensure that the default drive points to the one with the APL system diskette; the STSC system isn't picky about its drive.

The STSC system accepts an optional account number on the command line. At startup, it looks on the default drive for a workspace named INIxxxxx, that is, INI suffixed with the account number you entered (or 0 if none specified). If a workspace or that name is found, it is loaded. As usual, that workspace can automatically begin execution by appropriately specifying its latent expression.

The IBM system needs a minimum 128K of memory, an 8087 floating-point coprocessor, and a color/graphics board and monitor. The STSC system needs a minimum 128K and a monochrome or color/graphics board and monitor. APL⋆PLUS will use an 8087.

With the IBM system you have several choices at startup. This is the point at which you must decide which auxiliary processors you'll be using this session, and whether you'll be using the dyadic format primitive, a function that formats numbers to produce a character array (with APL, of course, not necessarily displayed). These decisions must be made at startup, because there's no way to access an AP (or dyadic format) unless it's made part of the system when you invoke APL.

The most curious aspect of IBM's system is its dyadic format, the code for which resides in a separate module called EXAPL.COM. Why split off dyadic format? For that matter, why split off any APL primitive? This is a mystery. Most people's view of APL is as a monolithic whole—it's all there. To chip off a primitive from a block and make it optional sounds odd.

For that matter, why not include all the APs, too? You can try to create a batch file which calls APL with EXAPL and all the APs as its arguments, but that doesn't quite work. There are seven names you'll need to include on the command line (6 APs plus EXAPL), but only six will fit. So you might omit the music AP and be done with it.

The IBM system also allows an optional system command at startup so you can load a workspace, which can then begin execution automatically via its latent expression.

Workspaces and Data

Once you get into either system you have a very powerful language at your command. Both systems support a workspace with a lot of memory. The STSC system uses all contiguous memory you might have, looking in the BIOS data segment at segment 40H to determine your machine size. The IBM system uses up to 544K only. Both companies are to be commended for their use of the system's memory—not many programs on the PC use as much memory as these two do.

The STSC system, whose features are contained within, provides about 20,000 bytes more workspace—minus the music AP—than a fully-loaded IBM system. Actually, with a 576K machine, I got an additional 32K of workspace.

The IBM system supports the usual four internal datatypes: Boolean (1 bit per element); character (1

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byte per element); integer (2 bytes per element); floating-point (8 bytes per element).

The STSC system supports just three of the above datatypes, omitting Boolean. This is a major shortcoming as it discourages the use of certain sorts of algorithms. Both systems deserve high marks for using the IEEE format for storing binary floating-point data.

Both systems have limits on data size. STSC limits you to 64K bytes per object. The IBM limits you to 32K bytes, but there's a catch, which needs explanation.

IBM uses a two-part workspace. In the main workspace, computation takes place and all data objects are created or modified. Objects can remain in the main workspace as long as the space they occupy isn't needed for some other calculation. If the space is needed, objects are moved to the elastic workspace (this is transparent to the user, except by the time it takes). This means that for every primitive calculation, the arguments must be brought in, and the result created, in 60K (64 K minus overhead).

This raises a couple of problems. For one thing, it's a lot of data movement! For example, if a 32,000-byte array isn't in the main workspace it costs over 900 milliseconds just to determine its shape. If it were already in the main workspace, the shape could be obtained with no measurable cost. That makes it nearly impossible to tune algorithms, because of both the 900 ms spike in timings and the difficulty in determining where your data are.

Another problem with IBM's approach to workspace management is that though the system ostensibly allows up to 32 K per data object, the size of the main workspace may impose a lower limit. For instance, although you might be able to get the shape of your 32,000-byte array, you won't be able to add it to another similarly shaped array, because you can't fit two 32,000-byte arguments and a 32,000-byte result into 60K. Thus, given the size of a data object and the sorts of operations you want to perform, you may have to limit yourself to less than the allotted 32 K.

Character Set Display

As mentioned, IBM uses the color/-graphics board/monitor to generate the special APL characters. STSC supplies its own ROM which works in either the monochrome or color/-graphics board.

The STSC ROM in the monochrome board provides crisp APL characters, which can't be matched by either company on the graphics board. "The STSC character generator is a real plus if one is doing any serious APL programming," says

Although the IBM system ostensibly allows up to 32K per data object, the size of the main workspace may impose a lower limit.

Joey K. Tuttle, branch manager of research at I.P. Sharp Associates, a leading supplier of APL applications and system software and APL time sharing services.

The ability to display the APL characters is not without cost. About 55 of the characters in the original ROM have been axed to enable the STSC to display APL symbols.

Will you miss any of the 55 excised characters? This is the question you need to ask yourself, as you're not likely to switch ROMs with the same frequency as you switch diskettes. Characters changed from the old ROM include novelty characters (e.g., the playing card suits, except the diamond), Greek characters (gamma, pi, upper and lower case sigma, etc.), mathematical symbols (radical sign, two characters which form the upper and lower parts of an integral sign, etc.), and a number of others. Some applications on the market are beginning to use a few of the excised symbols (like the filled-in arrow heads and the one-half and one-quarter symbols), but in general the characters you need are still there. Finally, the question boils down to how much you're going to use the product. The reduced eyestrain of seeing APL characters on the monochrome screen is a plus for any serious user.

APL Characters and the Keyboard

Because the APL character set contains many more characters than are available on single keys or in combination with the usual shift key, the systems need to devise an additional way to enter these characters. The extra characters (like logarithm, domino, etc.) are usually entered using the Alt key, but not consistently. The most widely used APL keyboard that has the composite APL symbols as single keys is the IBM 3270 series. The STSC system follows that layout almost to the letter. The IBM follows it mostly, but misses on about six characters, and on the change to the ISO standard keyboard layout, which for the APL-ASCII Overlay Convention moved the APL right arrow from shift-left arrow to the unshifted key to its right. The STSC system caught the change.

Users of the IBM key layout have not been happy with it. Says Joey Tuttle, "IBM has reproduced the worst features of 2741s and 3270s . . . and ignores completely the fact that the PC keyboard is an ISO standard layout. In general, the STSC treatment of the keyboard is all right, athough a few more refinements could be made."

On both systems, lowercase characters are entered via the Alt key with the corresponding letter. These lowercase letters may be used in identifier names.

Input Editing

Both systems provide access to inputs and outputs still on the screen. Both allow you to move the cursor to any line on the screen, modify it or not, and press ENTER to execute it. From there, they differ.

The STSC system makes editing of the selected line very convenient. Its list of editing features is extensive. The left and right cursor keys perform as expected, as well as the TAB and shift-TAB keys. Moreover, HOME and END move the cursor to the beginning or end of the line. DELETE removes the character at the cursor, and BACK (above the ENTER key) deletes the character to its left. Also, there are keys for clearing the entire screen, clearing the screen from the cursor to the end, clearing the current line from the cursor to either end, or deleting the current line from the screen and scrolling up the lines below.

On the STSC system, there is no replace mode. You are always in insert mode. It may take you a while to get accustomed to this.

On the STSC system, the INS key is used as an alternate means of entering composite APL characters. For example, if you've forgotten where the quote-quad symbol is on the keyboard (or forgotten how to enter it), you type quad, INS, quote. After you have pressed the INS key, the blinking cursor moves to the left one character position to the quad and, continuing to blink, fills the character matrix to indicate the change of mode. When you press the quote key, the desired composite character is produced. The composite APL symbols are also available as single keys in conjunction with the Alt-key.

On the STSC system, input lines longer than screen width are handled via a continuation character (the underbar) automatically generated by the system. A single input line of up to 511 characters can be entered and edited this way.

One problem with the STSC approach is that if you re-execute a previous line on the screen, its result is displayed directly below it and whatever was there before is not automatically cleared. Instead, the new result overwrites the old result. This can lead to confusion if the new result is shorter than the old one. The trailing characters of the old result appear after those of the new. To be safe, you must go to the end of the line and clear to the end of the screen. I know of one senior APL systems programmer who, because of this problem spent many hours trying to find out why ⎕*TS* occasionally printed four digits in the millisecond position.

STSC's system provides no access to lines scrolled off the top of the screen.

The IBM system's approach to input editing preserves the sequence of executed lines. Once you've selected a line to modify you may delete single characters or all characters to the right of the cursor.

> *Like the IBM system, STSC has weak and strong interrupts. It's also checked with many primitives, which help tame runaway programs.*

The system is normally in replace mode—characters entered on top of existing characters replace them. The INS key toggles between replace and insert mode during editing. After the line is entered, the system reverts to replace mode. When you press ENTER on the line, it is copied to the line below the last line displayed on the screen and executed, thus preserving sequence.

A few hints: Lines longer than the screen width cannot be entered or edited without help from an auxiliary processor and the EDIT workspace distributed with the IBM system. No access is provided to lines scrolled off the top of the screen. The TAB key does nothing useful unless you redefine it with a program like PROKEY.

Keyboard Usage

With the IBM system, the ESC key is used to interrupt execution. Pressing it once generates a weak interrupt (halt at the end of a statement); pressing it twice generates a strong interrupt (halt as soon as the statement is detected). I noticed while doing the benchmarks of the IBM system, that the strong interrupt does not happen to be detected within a primitive, and some of the primitives can take a very long time. Thus, once you start it, you had better be prepared to finish it. Oddly enough, a weak interrupt also triggers an event if execution is under the control of the system function ⎕*EA*. A weak interrupt also cancels all output until the interrupt is acted upon. If you have an IBM Graphics Printer and you load the printer auxiliary processor AP80 at the start of your session, Shift-PrtSc will dump the contents of the screen to the printer. Ctrl-PrtSc toggles on/off sending input or output to the printer as well as sending it to the screen. If you make the mistake of hitting Ctrl-Break, you'll find yourself back in DOS.

One other annoying drawback of the IBM system is the lack of type-ahead. It would be very convenient to be able to enter the next line or two before the current one has finished processing. But with IBM you can't. This drawback is puzzling because the system doesn't steal the keyboard interrupts. Thus there is the usual DOS-provided 15-character type-ahead buffer, but it is ignored. On the other hand, because the keyboard interrupts are DOS's, keyboard enhances like PROKEY can be used. For instance it's possible to define usefully the TAB keys. No means is otherwise provided to define the function keys.

With the STSC system, Ctrl-Break is used to interrupt execu-

tion. Like the IBM system, STSC's system has weak and strong interrupts. It's also checked with many primitives, which help tame any runaway programs. Unlike the IBM system, the STSC system doesn't trigger an exception with its interrupt. Shift-PrtSc and Ctrl-PrtSc, which send output to the printer, are always available because the STSC system is integrated with its printer interface. There are also key combinations that pause and resume output as it is being displayed, as well as keys to slow it down.

The STSC system provides its own keyboard handling routines, with, among other things, a 160-character type-ahead buffer. On the one hand, this seems to be a nice feature, one that DOS should have. On the other hand, this means that programs like PROKEY cannot be used. There is, though, a distributed workspace where function keys in their unshifted, shifted, and control forms can be defined.

System Features

Both systems support a full set of APL primitives and system functions.

The IBM system is mostly VSAPL with some features, such as a peek and poke facility, added specifically for the PC, and some features, such as support for tabs, removed. It also contains features from APL2, IBM's experimental mainframe offering, such as picture format and the transfer form. Other features such as printer support, full screen function editing, access to PCDOS files and the operating system are available through auxiliary processors.

The STSC system provides system features through system functions—plenty of them. Thirty-one additional system functions alone support its two file systems, one a component-oriented APL file system, the other a native file system that provides access to any kind of PCDOS file.

System Commands

With a few exceptions, both systems provide the usual collection of workspace inquiry and management commands. The IBM system has two kinds of disk storage formats for APL objects: the usual workspace (.APL), and another form called a transfer file (.AID). The workspace contains APL objects with the execution stack and the workspace environment. The transfer file contains named data and function objects only. It is managed via)IN and)OUT, which transfer objects between the active workspace and the transfer file. The transfer file is vital because there is no)COPY command in the IBM system, and so there is no way to

copy objects from a saved workspace to the active workspace. To copy objects from your previous work, you save them in transfer file format. In a sense, then, saved workspaces represent work-in-progress and saved transfer files represent completed work.

Curiously,)IN cannot bring in objects if the active workspace has any suspended functions. So if you get partway through the executions of a code, and find you need some other function or variable, you have to clear the suspensions, bring in the other function or variable, and start over.

While the STSC system does not support transfer files, it does allow you to)COPY objects. Suspended functions do not bother it.

More shortcomings of the IBM system: Rather than displaying alphabetically, as they do with the STSC system,)FNS and)VARS display in the same order they were entered into the symbol table. And where the STSC system's)XLOA allows you to load a workspace without executing its latent expression, the IBM system has no counterpart.

Numeric Accuracy

When it comes to numeric accuracy, or the exactness of results, both

> *With a few exceptions, both systems provide the usual collection of workspace inquiry and management commands.*

systems have some shortcomings. As mentioned, both systems use the 8087 for all floating-point calculations and for calculations involving integers outside the range ¯32768 to 32767 .

Few problems could be found with STSC's 8087 algorithms. Things like `1E105-10*105` or `1E¯17-10*¯17` are non-zero (differing in the last bit—the 1E forms are correct) which implies some inaccuracy in their exponentiation routines. Their software simulation routines also occasionally are inaccurate. For example, 25 ×÷25 isn't exactly 1 using the simulation; the same expression works fine when using the 8087.

The IBM system suffers from similar problems at lower thresholds. For example, `1E16-10*16` and `1E¯1-10*¯1` (or `1E¯1-÷10`) are both non zero.

Beyond this, though, the IBM system has serious numeric accuracy problems. Some are perhaps excusable because they involve arguments outside one's normal computational domain. Others are less excusable. Hardest to understand is the fact that `10* 5 5` returns two

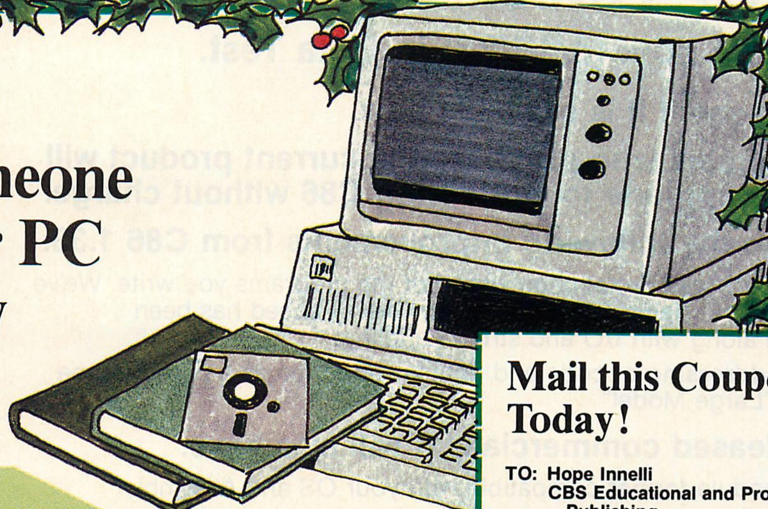
different numbers! That is, `-/10* 5 5` is non-zero. To be sure, the two numbers are close (the second result is one bit low in the last place), but that's no excuse. A general-purpose exponentiation algorithm using the 8087 isn't easy to get right; whatever algorithm is employed, results should be repeatable.

Also, as Cory Skutt, an independent consultant in San Antonio, TX, pointed out, the IBM system gives the result of `2| ¯1+2*51` as `¯1`. That's not even in range. It's also possible to construct a two-element vector (say `Q`) such that `Q-Q[2]` returns two non-zero values. This quirk occurs because the indexing primitive attempts to do type-demotion from 8-byte floating point format to 2-byte integer format (a questionable idea), but does so inaccurately. Thus if `Q[2]` is almost an integer (but not exactly so), it will be rounded to one anyway.

The list of such errors generated by the IBM system goes on and

The IBM system has serious numeric accuracy problems. Frequently, there are errors related to rounding in the last position.

on. Frequently, for instance, there are errors related to rounding in the last position. The 8087 provides four separate rounding modes: round to nearest or even (the default), round up (towards positive infinity), round down (towards negative infinity), and chop (towards zero). Unless one is doing certain special purpose calculations (like interval arithmetic), the best mode is generally the default. STSC uses this, but IBM uses chop, which likely is a partial cause of rounding-related errors.



Numeric Input/Output Conversion

When you enter two distinct decimal numbers that can be represented distinctly in the machine's floating-point format, you'd like them to be so represented. If two numbers in the machine are computationally distinct (e.g. their difference is non-zero), then you'd like to be able to display them distinctly, too. These issues are in the domain of input and output conversion.

According to the latest Draft ISO APL Standard, an APL system should provide two forms of output conversion: formatted and unformatted. The former is used by dyadic format; the latter is used by the system for default output and is dependent on print precision. Let's discuss the latter case first.

The term *full print precision* refers to the minimum number of significant decimal digits needed to distinguish the decimal representation of two machine-representable numbers. For the IEEE double-precision floating-point formula used by these two systems, the full print precision is 17.

As it happens, although both systems use IEEE format, neither allows full print precision. STSC limits ⎕*PP* to 16 digits, IBM to 15. Relatively speaking, that means you'll have less trouble with I/O conversion on STSC's system.

While you can find on both systems a pair of numbers that are computationally distinct, the systems won't distinguish their display when using default output (which uses print precision). For example, function line display uses maximum print precision. On both systems it's possible for an expression in a function line to display as 1000000-1000000 but compute a non-zero difference.

Another test of input/output conversion is whether

0≠*X*-⍎⍕*X*

is true for any X, with ⎕*PP* at its maximum allowable value. By definition, if ⎕*PP* is allowed to reach

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full print precision, this can never occur. A function that tests the above inequality using random numbers generated by (?32767) ÷ 32767 stops quickly on both systems with a value which satisfies the inequality.

For the second form of output conversion, formatted output produced by dyadic format, the programmer specifies exactly how many significant digits are desired. The issue is then one of proper rounding for display. Neither system works perfectly here. On the IBM system, for instance, 15⍕2 is 1.999999999999999 (15 of them). The STSC system doesn't share this problem, but fails to produce all the significant digits necessary to represent certain numbers.

Input conversion occurs when you enter numbers either from the keyboard or through execute. A system should accept at least full-print-precision-significant digits in this case. In fact, there's no reason it shouldn't accept as many digits as are entered. Again, neither system fully satisfies these needs.

The ISO Draft Standard rule is that every internally-representable number should have a distinct output form and should be accessible through some sequence of digits entered from the keyboard.

Numeric input and output conversion is not an academic matter: Real programs encounter it. Any time you transfer numeric data in any form (e.g. numeric constants in functions, or numeric variables) to the PC, you may run up against the above-mentioned limitations. In my mind there's no reason to lose precision unnecessarily.

Printer Output

Both systems provide access to the printer—STSC via internal code, IBM via an auxiliary processor.

The STSC system supports parallel and serial printers, five different translation codes including EPSON dot graphics, and the

transmission protocols XON/XOFF and/or RTS/CTS. It allows you to specify which of two serial or three parallel ports to use, as well as reading from the screen directly to the printer. Sample output is contained in figure 1.

The IBM system supports the IBM Graphics Printer only, not, for example, an EPSON FX-80. It's possible to print data on an FX-80, but not all APL characters will be properly graphed (the upstile for instance). (In figure 2, character positions 141 through 223 [except 172], 238, 239, and 254 are not displayed correctly because they were done on an FX-80.

In the IBM system, most special APL symbols are printed in graphics mode at 10 pitch only. Strangely, if you attempt to print text in other than 10 pitch (say in compressed mode), a line that contains a mixture of graphed APL symbols and others (for example, letters and numbers) is printed in two pitches. The graphed APL symbols are 10 pitch; the other symbols are on the same output line but are superimposed and printed at the pitch at which the printer is set. The mixture is hard to read.

> *IBM supports the IBM Graphics Printer only.*

The STSC system has no such problems.

File Systems

Both systems provide access to PCDOS files. The IBM system does this through AP210 in conjunction with a distributed transfer file. This arrangement seemed to work passably well, but it isn't designed to manage APL data. It does not, for instance, support replacement of variable length records. Eric Baelen, director of business systems development for RCA, expands, "I cannot deal with IBM's file system, be-

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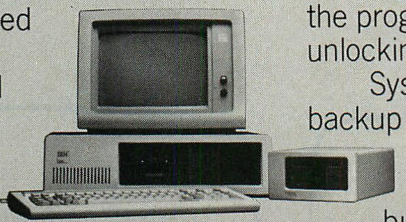

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cause it does not allow replacement of variable-sized data."

Along with a native file system, which manipulates PCDOS files, the STSC system has a component-oriented APL file system which can be used for storing and retrieving APL data. In that file system, you can easily replace variable length components: Components are referred to by number and may be read or written to in any order. This file system is nearly identical to the one jointly designed and implemented by STSC and I.P. Sharp Associates in 1969-1970. It has become nearly an industry standard in the APL community.

Figure 1: STSC Printer Output

0	NUL	26	→	52	4	78	N	104	h	130	é	156	£	182	╢	208	╨	234	χ
1	⍎	27	ESC	53	5	79	O	105	i	131	â	157	¥	183	╖	209	╤	235	≁
2	≠	28	⊣	54	6	80	P	106	j	132	ä	158	⍮	184	╕	210	╥	236	∇
3	⍷	29	⊢	55	7	81	Q	107	k	133	à	159	⍨	185	╣	211	╙	237	⍞
4	⋄	30	⍋	56	8	82	R	108	l	134	≠	160	á	186	║	212	╘	238	∊
5	¨	31	⍒	57	9	83	S	109	m	135	ç	161	í	187	╗	213	╒	239	∩
6	←	32		58	:	84	T	110	n	136	ê	162	ó	188	╝	214	╓	240	≡
7	BEL	33	!	59	;	85	U	111	o	137	ë	163	ú	189	╜	215	╫	241	⍙
8	BS	34	"	60	<	86	V	112	p	138	è	164	ñ	190	╛	216	╪	242	≥
9	HT	35	#	61	=	87	W	113	q	139	ï	165	Ñ	191	┐	217	┘	243	≤
10	LF	36	$	62	>	88	X	114	r	140	î	166	ª	192	└	218	┌	244	⍒
11	⊂	37	%	63	?	89	Y	115	s	141	Γ	167	⍀	193	┴	219	█	245	⍋
12	FF	38	&	64	@	90	Z	116	t	142	Ä	168	¿	194	┬	220	▄	246	÷
13	NL	39	'	65	A	91	[	117	u	143	L	169	⌷	195	├	221	▌	247	¨
14	⊃	40	(	66	B	92	\	118	v	144	É	170	ÿ	196	─	222	▐	248	°
15	●	41	)	67	C	93	]	119	w	145	∆	171	⍢	197	┼	223	▀	249	○
16	⌹	42	*	68	D	94	^	120	x	146	×	172	⍣	198	╞	224	α	250	∨
17	⍂	43	+	69	E	95	_	121	y	147	ô	173	¡	199	╟	225	ß	251	⍴
18	⍸	44	,	70	F	96	`	122	z	148	ö	174	«	200	╚	226	⍳	252	∪
19	⍫	45	-	71	G	97	a	123	{	149	⎕	175	»	201	╔	227	⍤	253	¯
20	ù	46	.	72	H	98	b	124	¦	150	û	176	░	202	╩	228	⍥	254	∣
21	⌶	47	/	73	I	99	c	125	}	151	⍌	177	▒	203	╦	229	⍫	255	
22	⍋	48	0	74	J	100	d	126	~	152	⌸	178	▓	204	╠	230	⊥		
23	⍵	49	1	75	K	101	e	127	DEL	153	Ö	179	│	205	═	231	⊤		
24	↑	50	2	76	L	102	f	128	Ç	154	Ü	180	┤	206	╬	232	⌽		
25	↓	51	3	77	M	103	g	129	ü	155	¢	181	╡	207	╧	233	⊖		

Remote Communications

Both systems provide a means of communicating with remote computers. With the STSC system, you turn on your modem, set the BPS rate with the DOS MODE command, enter APL, and press Alt-F8. At that point you can enter the usual modem commands. It's also possible to communicate with the modem under program control via a system function. STSC includes a workspace to aid you with doing this.

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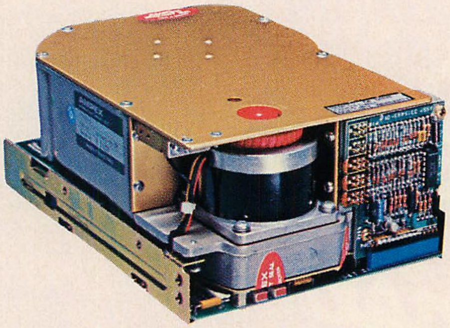

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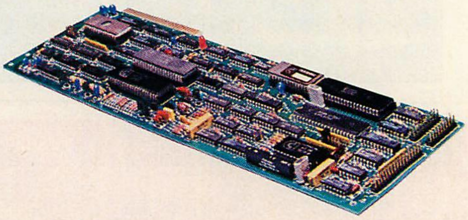

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an auxiliary processor (AP232) in conjunction with a transfer file included on the system disk. Unfortunately, the design seems oriented towards acoustic couplers or direct connections to the remote computer, and I couldn't get it to work with a Hayes Smartmodem.

Benchmarks

This topic is clouded by the numeric inaccuracies in the IBM implementation. My criticisms are based on the assumption that IBM can correct its accuracy problems without penalizing execution speed overmuch.

One large problem with benchmarking the IBM system is the 900 millisecond penalty that it exacts to empty the main workspace when it gets full. In general, it's very difficult to achieve repeatable timings because of this penalty. It's almost enough to make one give up belief in deterministic events. The timings on the STSC were rock-solid.

Figure 2: IBM Printer Output

0		26	<	52	⍺	78	Q	104	p	130	LF	156	ü	182	6	208	P	234	‼
1	←	27	≤	53	⍵	79	R	105	q	131	BS	157	°	183	7	209	Q	235	♂
2	→	28	⍲	54	à	80	S	106	r	132		158	é	184	8	210	R	236	♀
3	↑	29	⍱	55	'	81	T	107	s	133		159	£	185	9	211	S	237	♫
4	↓	30	^	56	;	82	U	108	t	134	⎕	160		186	:	212	T	238	☼
5	∊	31	∨	57	]	83	V	109	u	135	⍞	161	´	187	;	213	U	239	è
6	⍳	32	⍋	58	[	84	W	110	v	136	'	162	″	188	<	214	V	240	`
7	⍴	33	⍒	59	)	85	X	111	w	137	R	163	#	189	=	215	W	241	@
8	,	34	⍝	60	(	86	Y	112	x	138	▼	164	$	190	>	216	X	242	"
9	?	35	⍉	61	:	87	Z	113	y	139	⍫	165	%	191	?	217	Y	243	#
10	~	36	⊖	62	A	88	Δ	114	z	140	¨	166	&	192	@	218	Z	244	$
11	○	37	⌹	63	B	89	a	115	⍙	141	Ä	167	'	193	A	219	[	245	%
12	+	38	⍕	64	C	90	b	116	_	142	à	168	(	194	B	220	\	246	&
13	−	39	⍎	65	D	91	c	117	¯	143	ç	169	ù	195	C	221	]	247	¶
14	÷	40	⌶	66	E	92	d	118	0	144	ò	170	*	196	D	222	^	248	§
15	⍟	41	⊥	67	F	93	e	119	1	145	¿	171	+	197	E	223	_	249	↨
16	*	42	⊤	68	G	94	f	120	2	146	R	172	∪	198	F	224	▬	250	↕
17	×	43	⌿	69	H	95	g	121	3	147	æ	173	-	199	G	225	☺	251	{
18	!	44	⍀	70	I	96	h	122	4	148	Ø	174	ì	200	H	226	☻	252	↔
19	|	45	/	71	J	97	i	123	5	149	ø	175	Ñ	201	I	227	♥	253	}
20	)	46	\	72	K	98	j	124	6	150	¨	176	0	202	J	228	♦	254	
21	⌊	47	∩	73	L	99	k	125	7	151	Ä	177	1	203	K	229	♣	255	
22	=	48	⍷	74	M	100	l	126	8	152	Å	178	2	204	L	230	♠		
23	≠	49	⊂	75	N	101	m	127	9	153	Ü	179	3	205	M	231	BEL		
24	>	50	⊃	76	O	102	n	128	.	154	ä	180	4	206	N	232	►		
25	≥	51	∘	77	P	103	o	129	NL	155	ö	181	5	207	O	233	◄		

Both systems provide accounting information for elapsed CPU or session time (they're the same if no I/O occurs). STSC's time is returned in seconds (possibly fractional); IBM's in an integral number of milliseconds. All times reported below are in milliseconds.

In order to properly interpret benchmark results, you must first know the timer resolution. I executed `(⎕AI-⎕AI)[2]` in a loop to look for the smallest non-zero value. This number should be the timer resolution—the smallest resolvable time span. On STSC, it's about 55 ms, which corresponds to

the PC's timer interrupt frequency of 18.2 per second. On IBM, it's between 5 and 6 ms! Clearly, IBM marches to the beat of a different drummer. Perhaps they've reprogrammed the 8253 timer chip directly. I'm not sure. In any case, these numbers tell us not to trust times that are a small multiple of these values. In all the timings reported on below, I've tried to ensure that actual times were sufficiently large to not be affected by noise caused by the timer resolution.

Knowing the timer resolution, I then attempted to separate the algorithm time from the storage management time, which was necessary because of the storage management scheme in the IBM system. This was not necessary with the STSC system. The following concerns algorithm times only, as best as I could do them. In all IBM timings I attempted to eliminate the 900 ms portion, although I may not have succeeded in all cases.

In general, the IBM floating-point algorithms are *significantly* faster than those of STSC—typically by a factor of 9 or 10 to 1. Exponentiation with the IBM is even faster, usually by a factor of nearly 40 to 1. One way IBM may have picked up speed over STSC is in the use of the 8087's exception handling for overflow and divide-by-zero. This way, the extra step of checking for those conditions (which occur rarely anyway) is taken automatically. The STSC system appears not to use an exception handler, however it's hard to believe that that lack accounts for the full difference.

One large problem with benchmarking the IBM system: the 900 millisecond penalty it exacts to empty a full workspace.

Reductions and scans on Boolean data are common operations in APL code, and over the years APL system implementors have created some impressively fast algorithms to deal with these cases. Unfortunately, neither system seems to use any of the standard. When dealing with reductions and scans, for instance, APLers typically implement stopping rules, without incurring any additional overhead, by using an algorithm discovered by E.E. McDonnell of I.P. Sharp Associates 10 years ago when he was at IBM [ref 1]. For example, ∧/ can stop when it encounters a zero in its argument, as can ∧\.

Now both systems properly recognize the associative functions with the scan operator and use the linear algorithm. But then, when they should go on to use a non-associative function <\ that could be implemented using McDonnell's linear algorithm, both systems use the quadratic algorithm instead. The IBM is the only one that could

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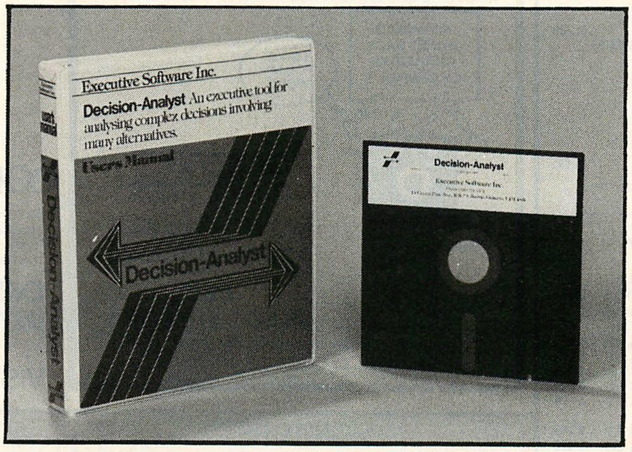
A life saving decision

I spent many sleepless nights trying to come up with a solution to this nightmarish situation. Then I remembered a course I had taken in decision analysis. I spent the rest of that night reviewing course material and other books I had bought on the subject. The next day, I called an emergency meeting.

Using the decision making techniques I had learned, we spent the rest of the week searching for and analysing potential solutions. The net result was that not only was the company pulled back from the brink of destruction, but we added over $1,000,000.00 in gross sales during that off-season.



A way of life

From that point on, almost every critical decision (and there were many) regarding new products, marketing channels, pricing, advertising, production equipment, engineering projects, received this same type of analysis.

Although the process was very time consuming and clumsy, because it had to be done by hand, our decisions were much improved. And there were some real benefits that we had not anticipated.

1. Our understanding of each problem was greatly increased.
2. We uncovered opportunities that we would not have thought of in any other way.
3. Our decisions were documented, preventing us from slipping off the selected path or 'rehashing' the same things over and over.
4. Consensus became easier because we were forced to focus and resolve each part of the problem, one piece at a time.

The birth of Decision~Analyst™

Decision~Analyst was created because the process of evaluating complex decisions with multiple alternatives and many criteria is very tedious and time-consuming if you do it on paper. And doing it in your head is virtually impossible.

Any complex decision usually requires multiple revisions to criteria, alternatives, weights and values assigned to them. If done manually, the ordeal of rewriting, recalculating and redocumenting tends to discourage revisions, thus producing poor results.

Decision~Analyst overcomes these problems by asking for the minimum input possible from you, in the correct sequence. It leads you step by step through the decision making process, then does all the necessary calculations and produces polished reports without any further effort. And all of your input is stored on your disk so that revisions and updates can be made easily at any time.

Comprehensive but easy to use

Decision~Analyst is probably the easiest program you'll ever use. You can literally learn to operate the program using only the 'help' screens. But it comes with a thoroughly indexed manual which includes many pages of examples plus a step by step guide to the decision making process.

And Decision~Analyst is no fly-weight. It uses over 100,000 bytes of fast compiled code and a 40,000 character help file. The program is extremely 'bullet proof' and does all the work . . . you do the thinking. And there is no danger of missing a critical step because your analysis is guided through each of the eight menu-driven sections.

Endless opportunity for use

If you're saying to yourself that you really don't have any earth shattering applications for Decision~Analyst . . . then consider this. If you're in business, chances are that the most important thing you do is make decisions.

Decision~Analyst can help you select key personnel, decide on new machinery or equipment, prioritize major projects and allocate resources, choose a new product or a better price strategy, select new offices or plant locations, select the most profitable marketing channel or the best piece of computer hardware or software. Use it to analyse any decision which has more than one viable alternative.

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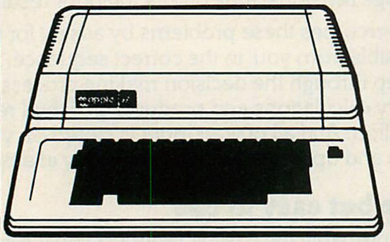

apple II+/IIe

	OUR PRICE
APPLE IIe. STARTER SYSTEM BY APPLE (System A) 64K and 80 column; Disk II with controller; Apple Monitor III; Monitor Stand	$1,650
APPLE IIe STARTER SYSTEM BY CONROY-LA POINTE [SYSTEM B] 128K and 80 column; 1 Micro-Sci Drive with controller; Filer. Utility and DOS 3.3 Diskette; Sanyo 9" Green Monitor; RF Modulator (for color TV); Game Paddles; Game with color graphics and sound; 20 Blank Diskettes	$1,695

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Rana Elite 1. 163K. 40 Tracks	$ 379	$ 249
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Elite 3. 652K. 160 Tracks	$ 849	$ 499
Elite Controller w Manual & Diskette	$ 145	$ 84
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Controller Card.	$ 89	$ 69
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VISTA Solo. 5" 143K Disk Drive Std. Height	$ 300	$ 249
Controller Card	$ 89	$ 75
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★ **CCS.** Serial Interface 7710A (Can Set Baud)	$ 150	$ 99
★ **ComX**. 16K RAM Card. 1Yr. Warranty. for II+	$ 179	$ 39
Microsoft. 16K RAMCard for II+	$ 100	$ 69
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64K RAM Card for II+	$ 425	$299
128K RAM Card for II+	$ 599	$399
Silicon Valley. Word Handler	$ 250	$ 39
★ List Handler	$ 90	$ 35
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KOALA. Graphics Pad	$100	$ 75

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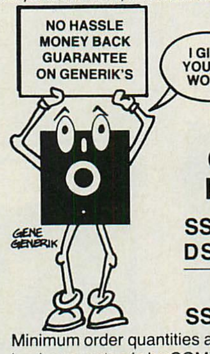

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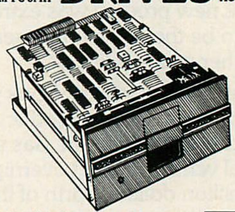

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★ 12" Amber, #300A	$ 210	$ 149
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★ 13" Color I, Composite	$ 379	$ 289
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★ 13" Color III, RGB, Commercial. (Ap. II, III)	$ 479	$ 399
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ZENITH, 12" Green, Model ZVM121	$ 150	$ 89

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MX100F/T, 80 CPS, with Graftrax +	$ 995	$ 639
FX100, CPS		Call
Apple II Graphics Dump Program	$ 15	$ 9
Graftrax Plus, specify for MX80 or MX100	$ 95	$ 79
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OKIDATA, Microline 82A, 80 col., 120 cps, Para., friction & pin feed	$ 549	$ 448
Microline 83A, 132 col., 120 cps, Para., friction & tractor feed	$ 899	$ 699
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Microline 93, 160 CPS, 136 Col., Para, Graphics	$1249	$ 969
ORANGE MICRO, Grappler +, for Apple, specify printer	$ 165	$ 119
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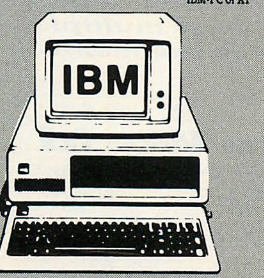

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actually use McDonnell's algorithm to its full potential, because only it has a separate Boolean datatype. Because of this, IBM is much faster than STSC, typically by a factor of about six.

Sorting is a common computer task, so common that both systems basically provide it as a primitive. The grade primitives (grade up/down) return the indices necessary to order the argument ascendingly or descendingly. Both systems provide a very powerful function, unmatched by any I have seen in other languages. It may be another of APL's unique contributions to computing. Thanks go to Howard Smith of IBM for the idea [ref 2]. Let's see how it works.

Here's a typical problem. Your defined function has a number of labels in it all of the form A1 to A99, B1 to B99, etc. Given a three-column matrix containing the names (left-justified), how do you put them in order? Not just any order, though. The alphabet prefixes must be in alphabetic order and within equal prefixes the numeric suffixes must be in numeric order. How do you get L2 to sort between L1 and L10? Will you have to split apart the prefixes and suffixes and sort them separately somehow? No! It can be done using the grade up primitive alone with an appropriately defined collating array as its left argument. They key is to break the bounds of thinking of a collating sequence as a one-dimensional vector in which the relative positions of two values determine their relative order. Instead, Smith conceived of a multidimensional collating array where relative order along rows determines two character's relative order. If the two characters compare equally along all rows, the algorithm shifts to compare them along columns, and so on to higher dimensions until the relative order is resolved. (See Smith's article.)

The collating array used in this benchmark is a 10-by-2-by-28-character array. It can be created using the code in figure 3. Figure 4 shows the code involved in sorting a matrix M according to the collating sequence CS. Smith's algorithm can be implemented quite efficiently without all the searching that the above description implies. STSC seems to have a better grasp of how to do this. For a 100, 250, and 500-row-by-3-column matrix, the STSC system took 275, 604, and 1044 ms respectively. For the same arrays, the IBM system took 7064, 11995, and 19033 ms.

What about real world problems? The answer must always take into account the 900 ms spike in the IBM system's timings. When dealing with code fragments any larger than a primitive or two and with reasonable-sized data it's very difficult to get repeatable timings. If the timings aren't stable, comparisons are less meaningful. How do IBM and STSC handle this prob-

Figure 3: APL Code Used to Create Benchmark Collating Array

```
CS← 10 2 28 ρ' '
CS[1;1;1+⍳26]←'ABCDEFGHIJKLMNOPQRSTUVWXYZ'
CS[2;2;1+⍳26]←'abcdefghijklmnopqrstuvwxyz'
CS[;1;28]←'0123456789'
```

Figure 4: APL Code Used to Sort a Matrix

```
      ⎕←M← 4 3 ρ'L20L10L1 L2 '
L20
L10
L1
L2

      M[CS⍋M;]
L1
L2
L10
L20
```

lem? Mostly, one is left with subjective impressions. Overall, the STSC system is faster.

Although the IBM system may have better algorithms in some cases, it suffers quite a bit from poor agoranomics, or space management. Shuffling objects in and out of the main workspace just to get them all under one segment register is slow: there's a severe execution penalty for any but the shortest piece of code. Those 900 ms spikes add up pretty quickly.

The Systems Compared

Table 1 shows a side-by-side comparison of the two systems. Positive number limit is the largest representable number in the system (obtained from L / ⍳ 0). Positive counting number limit says that all integers between 1 and this number are uniquely representable. Index limit is the largest subscript which may be used. Length limit is the maximum number of elements any array can hold. Rank limit is the largest allowed rank. Identifier length limit is the number of characters distinguished in an identifier name. It's quite small on the IBM system. Moreover, neither system signals an error if an identifier is entered which exceeds the limit. That's certainly less of a problem at 77 than it is at 12.

Miscellaneous

Neither system allows self-localized functions—user defined functions that re-use their name in the new context. The STSC system simply rejects such attempts. The IBM system usually chokes on them, either displaying a real live SYSTEM ERROR, or going belly up (system reset time). This SYSTEM ERROR message actually is a good sign as it implies that there are checks in the system of its own assumptions. Non-orthagonal internal design in a system this large and complex is unavoidable, so it's reassuring to see such checks in place.

One assumption IBM failed to check is the presence of an 8087. As you might expect, the system hangs on a CPU WAIT instruction preced-

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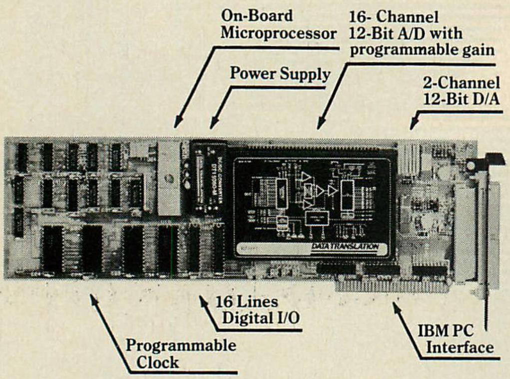

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ing an FINIT if the chip is not installed. That's a minor oversight. It would take only six instructions to determine its presence or absence.

The two systems support both monochrome and graphics monitors, although IBM supports the monochrome monitor only in conjunction with a graphics monitor. Of course, you can't get APL characters on the monochrome screen with the IBM system. As it turns out, the STSC character ROM on the monochrome screen correctly displays many of the IBM system's APL characters, but not enough to make it interesting. Those with both monitors, will find it very convenient to switch between the two (and between 40 and 80-column mode on the graphics monitor) on the IBM system. To make the switch with the STSC, you have to write a small but non-trivial APL program, which writes into the BIOS data segment, and more. This program is not provided with the STSC system, although it can be obtained from the company.

The STSC system allows end-of-line comments, IBM doesn't. In a limited-screen environment like that of the PC, it pays to make the most of the screen's space—end-of-line comments do this.

The STSC system supports values for *⎕PW* up to 255; IBM limits it to 80. Curiously, the default width in the IBM system is 79, not 80. Perhaps that's because output doesn't work quite correctly at width 80 (or 40 for that matter when in 40-column mode). For example, on the IBM system, a two-by-screen-width matrix of, say, A's prints on four lines—A's, a blank line, more A's and another blank line. This effect is most noticeable in 40-column mode when files are being listed on a diskette with)LIB. Each line of output is just 40 characters long, hence they're all double-spaced. Fully half the screen is wasted. Also, curiously at a *⎕PW* of 40 only two 13-wide columns of names are displayed from)FNS and)VARS although there is sufficient room for three columns.

Empty matrices display differently on the two systems. On STSC, 3, 2, 1, and 0-row matrices display on 3, 2, 1, and 0 lines respectively. On IBM, the same matrices display on 3, 2, 1, and 1 line. It is true that empty matrices in IBM's mainframe VSAPL program product behave the same way, but that system was designed in the early '70s. On IBM's experimental APL2 system, empty matrices are treated correctly, and in fact better than either PC system. The misdisplay of empty matrices is a hassle for programmers. They'll need to code special checks for such cases.

The IBM system supports ambivalent user-defined functions; STSC doesn't. Ambivalent functions are like primitives in that they may be called with or without a left argument. Within the ambivalent function, this condition can be tested for and the cases split. This very nice feature is slightly flawed in its implementation. The problem occurs for the careful programmer when writing a dyadic-only function. You must now remember to check for the absence of the left argument and then figure out what to do without it. Since there's no way in the IBM system to signal a SYNTAX ERROR to the calling environment, there's no way to mimic the way the system handles a dyadic-only primitive called with only one argument. You're left with no good choices. One solution is for the system designers to implement ambivalent functions in a way which distinguishes them for other user functions, perhaps with a marker in the function header.

The two systems also differ in their speed of display. The STSC system does direct writes to the screen buffers; IBM uses its own BIOS calls (perhaps there's a rule in

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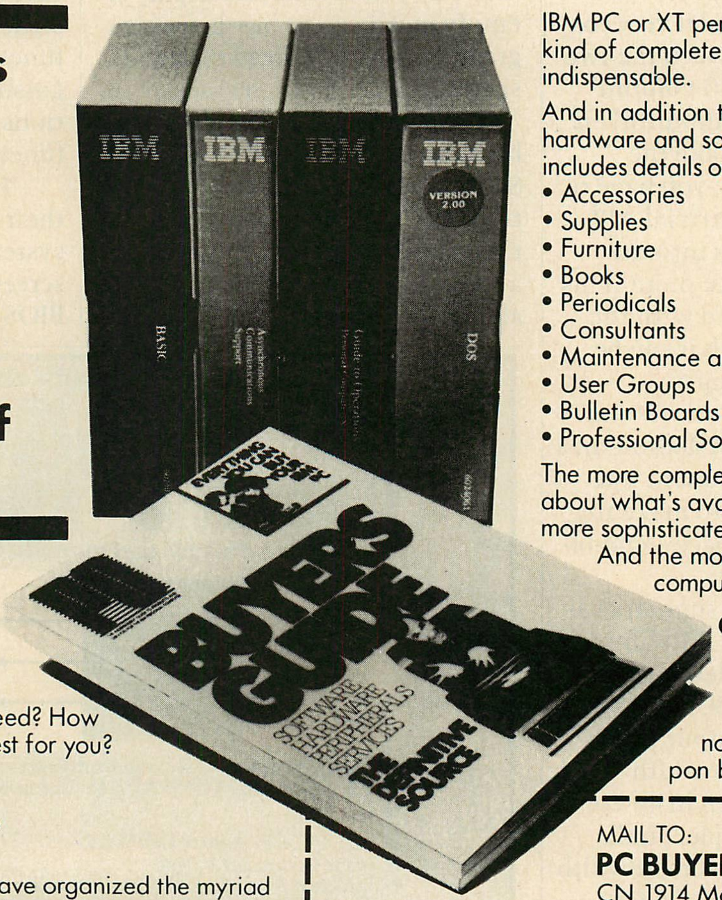

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IBM about that). In any case, the STSC system gives a much spiffier appearance as a result.

Summary

In the end, how does one choose? The STSC system has extensive features and is heavily documented. The ROM makes viewing the characters a pleasure. Its interface to the screen (not covered in this review), to PCDOS files, to BIOS (also not covered), to remote computers, to its input editor, and to the printer are all simple and straightforward to use.

The IBM system has lots of bugs and they're not all obscure. It has a number of shortcomings including a crude interface to the above-mentioned areas where the STSC system shines: numeric inaccuracy, and a poorly-designed storage management scheme. However, its floating-point algorithms put those of STSC to shame. Some of these shortcomings are more easily corrected than others. About the only one that likely would involve substantial work is the storage management problems. I look forward to another version that addresses these problems.

Also, there is a substantial price difference. You get a lot from STSC for $595, but the IBM system costs only $195 (assuming you already have an 8087 and a color graphics adapter and monitor).

As usual, you'll need to decide for yourself.

References

1. *McDonnell, E.E.,* The Caret Functions, Proc. of the Sixth International APL User's Conference, *Anaheim, Calif., 1974.*
2. *Smith, Howard J., Jr.,* Sorting: A New/Old Problem, APL79 Conference Proceedings, *Rochester, NY, Association for Computing Machinery, 1979.*

Table 1: ISO and APL Upclose

	IBM	STSC
Positive number limit	*1.7977...E308*	*1.7977...E308*
Positive counting number limit	*2*53*	*2*53*
Index limit	*32767*	*32767*
Length limit	*32767*	*32767*
Rank limit	*63*	*63*
Identifier length limit	*12*	*77*
Print precision limit	*15*	*16*
Full print precision	*17*	*17*
Function line limit	*1000*	*32767*


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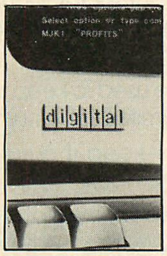

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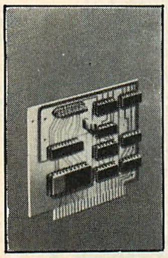

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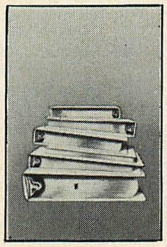

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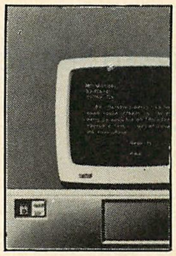

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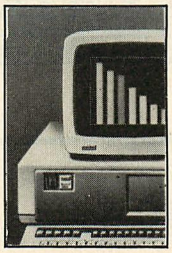

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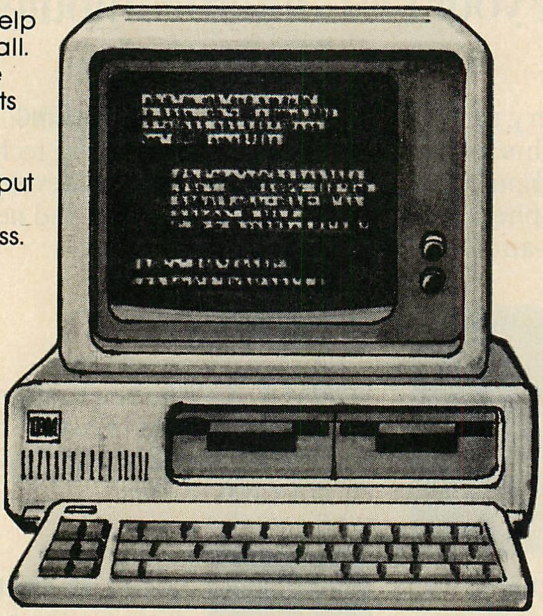

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Creating tables and searching for the existence of a particular entry is a standard software problem. Tables in BASIC, which are often in the form of numeric or string arrays, can be searched via FOR/NEXT or WHILE/WEND loops with an appropriate IF statement. More exotic techniques such as hash coding, linked lists, and the like, are overkill for small tables.

But the problem can be approached from another angle. Tables can be coded as a series of characters, i.e., a string variable, and quickly accessed with a single BASIC statement using the INSTR function. The key to this technique lies in properly coding the table as a string of characters.

In one variation INSTR takes two string-valued arguments and returns the starting character position in the first string where the second string can be found. If the second string is not found, a zero is returned. The command **INSTR("to be or not to be", "be")** returns a 4, whereas **INSTR("that's the question", "be")** returns 0.

The second variation of INSTR includes a numeric argument which is the character position where the search for the second string begins. **INSTR(5, "to be or not to be", "to")** returns a 14, and **INSTR(8, "to be or not to be", "or")** returns 0.

Without this argument the search will always begin with the first character in the string being searched.

Consider an invoicing system where a small set of payment terms that must be validated upon entry are used. The terms are phrases such as NET, COD, OTHER. Placing a unique character between each term, creates a string variable containing them that can be used for validation. (See listing 1.)

Concatenating the PT$ variable with backslashes on either side in line 120 insures that only valid matches are found in TERMS$. Without them an entry such as NET 3 would be considered valid.

Suppose you wanted a table look-up to return a sequential position number for the item found, and to validate an item. With INSTR, the table must be structured as a group of fixed length fields. Valid entries in the table will then always be found at character positions equal to a multiple of the field width plus one, where the entries are numbered from zero.

To determine position numbers for the above payment terms example, let each term take 7 characters in TERM$. Valid PT$ values will always begin at character positions 1, 8, 15, and so on. (See listing 2.)

Line 115 converts PT$ to a 7–character string with trailing dashes. As before, this is necessary to insure a unique match in TERMS$. The P-value is first used to validate PT$ and is then converted to the relative position in TERMS$ where PT$ was found.

INSTR can also be used to determine a second value associated with the table entries. A table with a few of the 8086 control mnemonics and their hexadecimal values, for example, can be accessed as shown in listing 3.

Ed Volkstorf's company, New Venture Systems, produces educational administrative software. His book, Graphics Programming on The IBM Personal Computer, *was published this fall by Prentice-Hall.*

LISTING 1 VALIDATION TABLE

```
100 TERMS$="/NET/NET 10/NET 30/COD/OTHER/"
110 INPUT"Enter payment terms: ",PT$
120 IF INSTR(TERMS$,"/"+PT$+"/") > 0 THEN 140
130 PRINT"Invalid.  Please re-enter." : GOTO 110
140 ...   ' terms ok;  program continues
```

LISTING 2 DETERMINING POSITION

```
100 TERMS$="NET----NET 10-NET 30-COD----OTHER--"
110 INPUT"Enter payment terms: ",PT$
115 PT$=LEFT$(PT$+"-------",7)
120 P=INSTR(TERMS$,PT$) : IF ((P-1) MOD 7)=0 THEN 140
130 PRINT"Invalid.  Please re-enter." : GOTO 110
140 P=P\7 + 1 ' calculate relative position in table
150 . . .     ' terms ok; program continues
```

LISTING 3 TABLE LOOK-UP

```
100 PROC.CTL$="/CLC,F8/CMC,F5/CLD,FC/CLI,FA/HLT,F4/LOCK,F0"
110 INPUT"Enter mnemonic: ",M$
120 P=INSTR(PROC.CTL$,"/"+M$+",") : IF P>0 THEN 140
130 PRINT"Invalid.  Re-enter." : GOTO 110
140 P=INSTR(P+1,PROC.CTL$,",")  ' find comma after mnemonic
150 H$=MID$(PROC.CTL$,P+1,2)    ' get hex for this mnemonic
```

INTERRUPTS AND THE IBM PC PART 1

Another gap in IBM documentation: How the 8259A interrupt controller works.

CHRIS DUNFORD

As Roseanne Rosannadanna so sagely observes, it's always something. I recently had to write a special purpose communications program, so I turned to my usual development language, Pascal. But it was lacking in support for communications. So I tried 8088 assembler. With it, I lost input data every time the program initiated disk or printer I/O. I tried C: the same problem. There was nothing left but BASIC, and I am no fan of BASIC. Even if I were, it would have been too slow to handle all the 1200 baud processing I had in mind.

So, I decided to go back to assembler and try to solve the lost data problem. As you know, data communications under the PC's scheme of things is an asynchronous process—one whose timing is not under program control. And you are probably also aware that communications support from DOS and BIOS is unbuffered. Combine these two, and you've got the essence of the problem: how to guarantee that a program will always be prepared to handle incoming data, given unknown arrival times for data, and the inability of DOS and BIOS to help?

The natural way to solve the problem is to use interrupts. In examining the PC's interrupt system, I found that it is very flexible and functional, but largely undocumented by IBM. Virtually ignored in the literature is the 8259A interrupt controller on the system board, the powerful and versatile chip that is essential to interrupt handling.

This two-part article will describe the PC's interrupt system in depth. Part I will examine the workings of interrupts: how they are triggered and serviced; how you can control the interrupt system on the PC. We'll spend considerable time in the depths of the 8259's microcircuitry. Next month, we'll demonstrate how to use the interrupt system by building a simple but functional interrupt-driven terminal emulator.

The interrupt technique is useful, because an interrupt can halt virtually anything, even DOS and BIOS routines.

A LITTLE BACKGROUND

There are two fundamental techniques for dealing with asynchronous data: polling and interrupts, both fairly simple concepts. Polling means checking periodically to see if certain things need attention. An automobile driver, for instance, polls things: At reasonably regular intervals, he polls the speedometer, the fuel gauge, the rear-view mirror, and so on. In terms of computer communications, polling would mean doing something such as periodically checking the RS232 port to see if data is available, and taking appropriate action if it is.

Now, polling is suitable in some cases, but it can't help very much with the problem at hand. In order to ensure no loss of data, the software would have to poll at least every hundredth of a second at 1200 baud. If the program were in control at all times, that wouldn't be very difficult, but the fact is that control is relinquished to the system every time service is requested from DOS or BIOS. During that time, no polling can take place. If the service requested is an I/O process such as disk or printer output, loss of data is virtually assured. So polling is ruled out as a valid solution here.

The second asynchronous data technique involves the use of interrupts, or signals indicating that something needs attention. A ringing telephone is an example of interrupts in the real world: It is an interrupt signalling the occurrence of an asynchronous event—a tele-

phone call. If there were no interrupt, we'd have to poll the telephone every 20 seconds or so to see if there were an incoming call. The red "idiot" lights in autos are interrupts signalling critical events; the manufacturer has saved us from having to poll a temperature gauge by adding an overheat interrupt.

In terms of computer communications, if the RS232 port were to interrupt when it had data ready, the system could go on about its business, ignoring the port completely until then. What makes the interrupt technique so useful is

Polling can't help with the lost data problem—the software would have to poll at least every hundredth of a second at 1200 baud.

that an interrupt can halt virtually anything, even DOS and BIOS routines. The communications program can do whatever it wants: scan the keyboard, initiate I/O processes, or play PC-MAN, secure in the knowledge that control will be regained whenever the RS232 port has data available.

INTERRUPTS AND THE PC

The 8088 microprocessor on the PC's system board is capable of responding to three basic types of interrupts: software, nonmaskable external, and maskable external. I'm assuming that you already have some familiarity with 8088 assembly language, and so know about software interrupts. Nonmaskable interrupts are usually reserved for critical events: impending power failures, reset keys, and the like. (In the PC, the maskable interrupt is used when parity errors in memory are discovered.) The final type, maskable interrupts, is the one we're interested in here.

A maskable interrupt is an interrupt from an external device that can be masked (ignored) if desired. (Note that external here means outside the 8088, not necessarily outside the computer.) The PC is designed to allow for eight maskable interrupts, and they are called IRQ0 through IRQ7 (IRQ stands for Interrupt ReQuest). As delivered, the PC uses three of these interrupts—IRQ0 is used by the system timer, IRQ1 by the keyboard, and IRQ6 by the diskette adapter. The rest are not used by the system software, although they are available for use by properly wired cards in the peripheral slots.

What are IRQs? They are essentially "hard wired" interrupt signals leading from peripherals, that tell the system which peripheral wants to be heard. As mentioned, the keyboard is wired to IRQ1. When you press a key, the keyboard uses IRQ1 to tell the CPU that it wants attention.

Figure 1 is a simplified block diagram of the interrupt system as implemented on the PC. Notice that the eight IRQ lines (one from the system timer, one from the keyboard, and six from the peripheral slots) are inputs to a chip designated as the 8259A PIC, and that a pair of lines leads between the 8259 and the 8088 CPU. It would appear that the 8259 in some manner takes eight interrupt inputs and converts these into a single interrupt to the CPU, and that is exactly what it does. The 8259 (formal title: Intel 8259A Programmable Interrupt Controller) is the heart of the interrupt system.

The best way to explain what the 8259 does is to run through an example. Let's look at what happens when a key is pressed on the keyboard, assuming, for the moment, that no other interrupts are

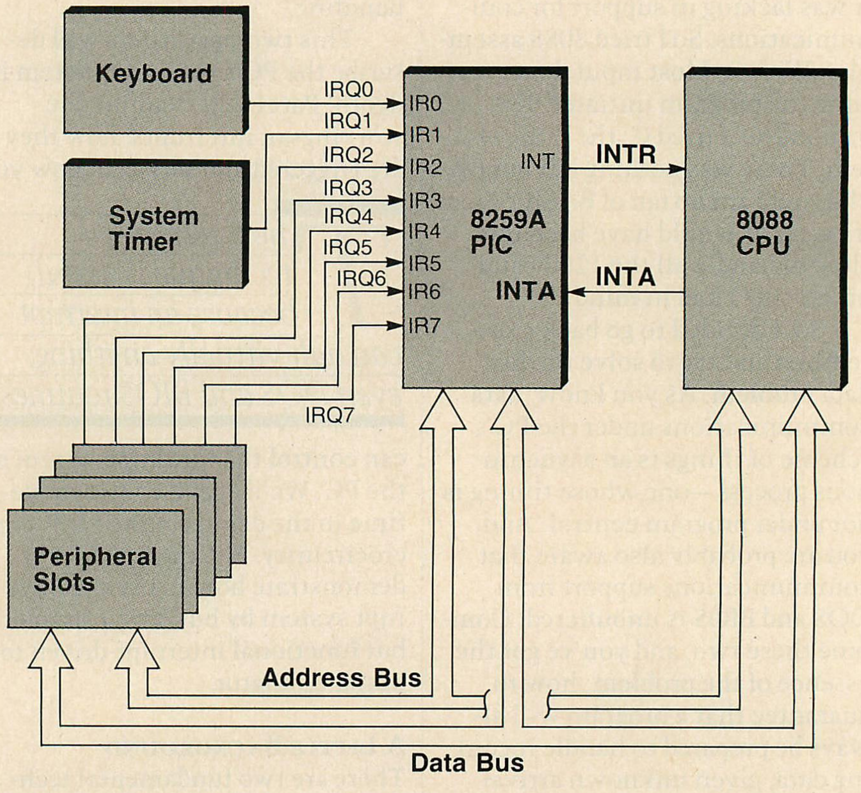

Figure 1: IBM PC Interrupt System—Simplified Block Diagram IRQ6 Used by Diskette Adapter Card

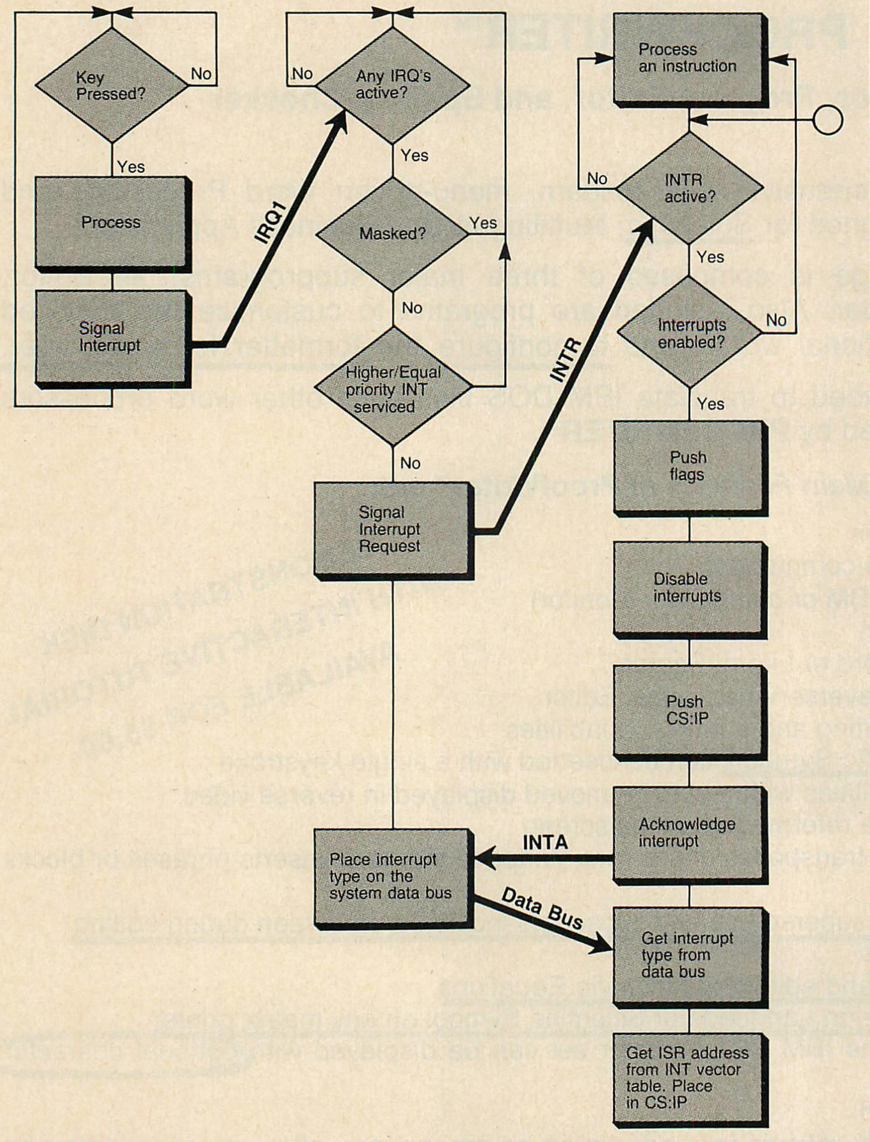

Figure 2: Interrupt/Acknowledge Cycle for Typical Interrupt. The final step of the 8088 process is, in effect, a jump to the interrupt service routine. The IRET at the end of the ISR restores the flags and continues execution at point A.

pending or in service. Figure 2 is a flow chart of a typical interrupt and acknowledge sequence. Note that double lines do not represent flow of control, but signals on various system lines.

1. There is a microprocessor in the keyboard that handles most of the work involved in keyboard scanning. When the processor senses that a key has been pressed, it determines which key it was and then sends out a signal to the 8259 (via IRQ1) indicating that it has data ready.

2. The 8259 checks to see if the interrupt is masked: is the system interested in IRQ1? It does this by looking at an internal 8-bit register called the Interrupt Mask Register (IMR). The eight bits in the IMR correspond to the eight maskable interrupts; IMR bit 0 is a mask for IRQ0, IMR bit 1 for IRQ1, and so forth. A one bit indicates that the corresponding interrupt is masked. In the PC, the 8259 finds a zero in bit 1 of the IMR, so IRQ1 is not masked. In other words, yes, the system is interested in IRQ1. (If the 8259 were to find a one in the bit corresponding to the current interrupt channel, no further action would be taken.)

3. Having determined that interrupt channel 1 is unmasked, the 8259 alerts the 8088 of the interrupt request by sending it a signal on the CPU's INTR input. You can think of INTR as standing for INTerrupt Request.

4. The CPU finishes any instruction it is currently executing and checks its interrupt enable flag. If interrupts are disabled (via a CLI instruction), no further action is taken, and the interrupt remains pending. If interrupts are enabled (via an STI instruction), the 8088 acknowledges the interrupt request, in effect saying, "I am now prepared to handle your interrupt." The CPU does this by sending a signal to the 8259 on INTA (INTerrupt Acknowledge).

5. The 8259 releases an 8-bit interrupt type number to the system data bus. This type number is constructed by adding the interrupt channel number—1, in this case—to a predefined base. In the PC, this base will be 8; thus, for IRQ1, the quantity released to the CPU is 9.

6. The CPU treats this quantity almost as though it were a software interrupt type; in other words, it behaves as though its next instruction was INT 9. It therefore begins executing the interrupt service routine whose address is the segment/offset address found at hex memory location 0000:0024. The flag register and CS:IP are saved, exactly as though a software INT 9 had been encountered in the code stream. The only significant difference between the CPU's behavior on a maskable interrupt and a software INT is that the CPU disables interrupts when it responds to a maskable interrupt.

Thus, in a rather roundabout way, the system executes an INT 9 instruction whenever the keyboard has information to send. One key point here is that *nowhere in the system software will you find an INT 9 instruction.* This is a hard-

ware interrupt; the combination of the IRQ1 signal and the 8259's logic causes the 8088 to suspend whatever it is doing and behave as though the next instruction were an INT 9. From that point on, of course, software takes over again. The INT 9 vector sends the CPU to an interrupt service routine which obtains the keyboard's data and handles it appropriately before returning to the interrupted program.

THE 8259'S COMPONENTS

The 8259 interrupt controller is a busy chip: It watches for interrupt requests from peripherals, maintains order by prioritizing multiple requests, keeps track of which interrupts are currently being serviced, masks unwanted requests, and more. All of this is under software control, which the remainder of this article will examine. The 8259 has many capabilities, but I will omit those not relevant to the PC. Full documentation is available from Intel (see references). Figure 3 shows a simplified block diagram of the 8259. The major blocks are as follows:

Interrupt Request Register (IRR): an 8-bit read-only register used to keep track of which peripherals are requesting attention. Bit zero corresponds to IRQ0, and so on.

The 8259 interrupt controller watches for interrupt requests from peripherals, prioritizes multiple requests, keeps track of which interrupts are currently being serviced, masks unwanted requests, and more.

In-Service Register (ISR): an 8-bit read-only register that specifies which interrupt levels are currently being serviced. Again, the bits correspond to IRQ lines. An ISR bit is set when an interrupt has been acknowledged by the CPU and the interrupt type number has been released to the system data bus.

Interrupt Mask Register (IMR): as described above, an 8-bit read/write register that is used to mask specific interrupts. A one in any bit indicates that the corresponding interrupt is masked.

Priority Resolver (PR): this important component combines the status of the IMR, the ISR, and the IRR, looks at some information it has regarding priorities, and then decides whether the *Control Logic* should assert an interrupt to the CPU via INTR.

These elements combine to control the operation of the 8259 and, hence, the entire maskable interrupt structure of the PC. In fact, what actually causes an interrupt

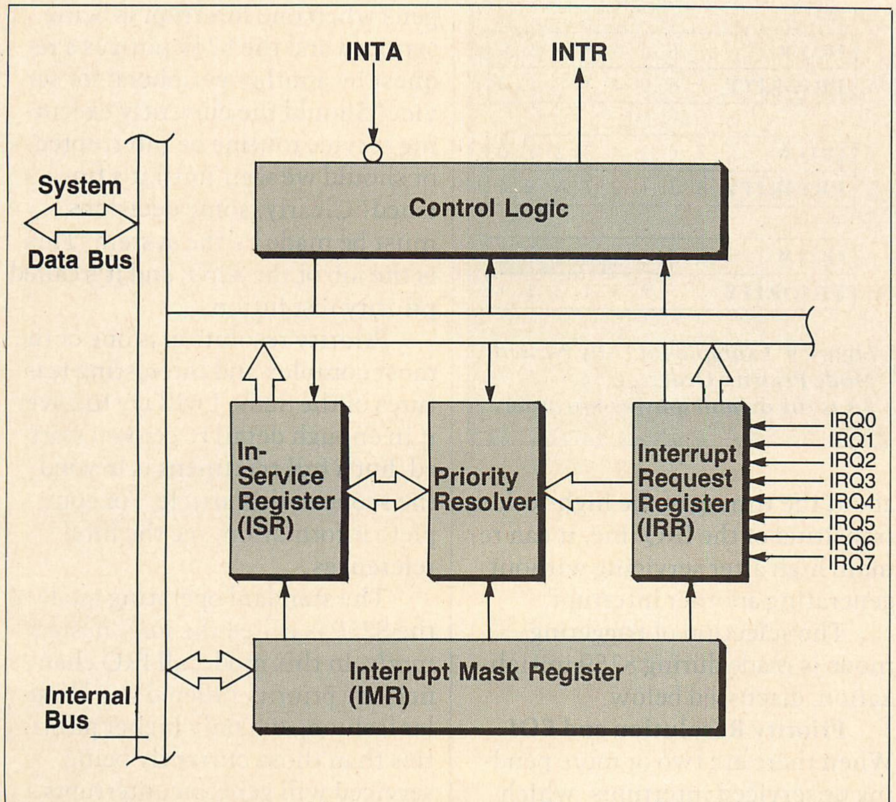

Figure 3: 8259 Programmable Interrupt Controller—Simplified Block Diagram

request to the CPU is a combination of a one in an IRR bit (peripheral requesting service), zeroes in the corresponding IMR and ISR bits (not masked, not currently in service), and a genial nod from the priority resolver.

Operation of the 8259

The operation of the 8259 can be divided into four categories: priorities, triggering, status, and vectoring. Let's look at each.

Interrupt Triggering One prerequisite for a CPU interrupt request is that an IRR bit must be set. What triggers the setting of an IRR bit? Obviously, the status of the associated IRQ line has a lot to do with it, but there's more. The 8259 has two triggering modes: level triggered and edge triggered. In the level triggered mode, an IRR bit will be set whenever its corresponding IRQ line is active. A consequence of this mode is that one

interrupt request from a peripheral can generate multiple interrupts; this will occur if the peripheral's IRQ line remains active after the interrupt service routine has signalled to the 8259 that servicing is complete. While there are uses for this mode, you probably won't have too much need for it on the PC.

The second mode, edge triggering, is the primary mode for the PC. In this mode, an IRR bit will be set only when an IRQ line makes the transition from low (inactive) to high (active). Thus, an IRQ line which goes active and remains active will generate only one interrupt because its IRR bit will be set only on the low-to-high transition. Another interrupt can only occur when the IRQ line has gone inactive and then back to active. The edge triggering mode is easier to work with from a programming standpoint for various reasons. For one thing, you need not worry

A	**IRQ #**	7	6	5	4	3	2	1	0
	PRIORITY	7	6	5	4	3	2	1	0
B	**IRQ #**	7	6	5	4	3	2	1	0
	PRIORITY	3	2	1	0	7	6	5	4
C	**IRQ #**	7	6	5	4	3	2	1	0
	PRIORITY	0	7	6	5	4	3	2	1

Figure 4: Examples of Fully Nested Mode Priority Ordering 4A is the default (power-up) order.

about the timing of the high-to-low transition of the IRQ line; it can remain high after servicing without generating another interrupt.

The selection of triggering mode is made during 8259 initialization, discussed below.

Priority Resolution and EOI

When there are two or more pending unserviced interrupts, which one gets serviced first? What happens when one interrupt is being serviced and the 8259 notices a request by another peripheral for service? Should the currently executing service routine be interrupted, or should we wait until it's finished? Clearly, some decisions must be made by the system. This is the job of the 8259, and it's called priority resolution.

Priority resolution is one of the most complex and interesting features of the 8259. I will try to cover it in enough detail to get you started, but a full treatment is beyond the scope of this article. For complete information, see the Intel references.

The standard operating mode of the 8259 is called the *fully nested mode*. In this mode, all IRQ channels are priority ordered in a circular fashion, and only higher priorities than those currently being serviced will generate interrupts. Figure 4 shows several examples of

priority ordering in the fully nested mode. In the figure, the lower the priority number, the higher the priority; thus, Priority 0 is the highest priority, and Priority 7, the lowest. Note the circularity of the priority levels. On initialization, priorities are ordered as in figure 4A, that is, IRQ0 has the highest priority, followed by IRQ1, and so on, down to IRQ7 with the lowest priority.

After the 8259 receives an interrupt acknowledgement from the CPU, it then decides which of the pending requests has the highest priority. As described shortly, the 8259 then determines the interrupt vector to be placed on the data bus for the CPU's use. Finally, it sets the corresponding ISR bit, indicating that the routine for this interrupt is currently in service.

In the fully nested mode, when an ISR bit is set, all interrupt requests of an equal or lower priority are temporarily inhibited; only requests of a higher priority will generate a CPU interrupt. For example (assuming that the scheme of figure 4A is in effect), suppose that the peripheral attached to IRQ3 has requested and been granted a CPU interrupt. As soon as the IRQ3 vector has been placed on the data bus, ISR bit 3 will be set. Until it is reset, the 8259 will not request a CPU interrupt for IRQ3 through IRQ7; only IRQ0, IRQ1, and IRQ2 will receive attention if they ask for it. It thus becomes clear that the resetting of the ISR bits is critical. It, in the

> *The resetting of ISR bits is critical, if they're to be granted interrupt servicing.*

above example, ISR bit 3 were never reset, IRQ3-IRQ7 would never be granted interrupt servicing. How does the ISR bit get reset? Through two EOI (*E*nd *O*f *I*nterrupt) commands, and one special EOI mode.

Non-Specific EOI Command. This software command tells the 8259 that the CPU has completed processing an interrupt, without specifying which one it was. The 8259 then resets the correct ISR bit. How does it perform this magic? Simple: In the fully nested mode, the service routine just completed will always be the highest priority routine of all currently active. This makes sense if you think about it for a while. If the 8259 will only generate interrupt requests for interrupts of higher priority than those currently executing, the current service routine must be the highest priority of those currently in service.

Therefore, while in fully nested mode, all you need do is issue a non-specific EOI command at the end of each service routine. The 8259 will correctly track which

routines are completed and which are not.

Specific EOI Command. In some cases (which will be described shortly), the 8259 may not be able to determine which EOI has been specified. In these cases, a specific EOI command is available; this specifies the exact ISR bit to be reset. The specific EOI command can be used at any time, even in the fully nested mode. However, the non-specific command is cleaner from a program structure point of view; you won't have to change the command if the interrupt number is changed at a later date.

Automatic EOI mode. The 8259 can be programmed into an automatic EOI mode. In this mode, the programmer does not send any EOI commands to the chip; the 8259 will automatically issue a non-specific EOI command to itself as soon as it has completed the interrupt/acknowledge sequence with the CPU. In effect, the ISR bits are reset immediately after they have been set.

The auto-EOI mode is one of two cases that destroy the fully nested mode. If the ISR bits are always reset, the interrupt controller has no way of knowing that any service routines are being executed. Thus (assuming interrupts are enabled), *any* subsequent interrupt will be serviced immediately, regardless of its priority. Automatic EOI has its share of difficulties.

When should you use automatic EOI? On the PC, probably never.

Suppose, for example, that you have programmed the 8259 into level triggering and automatic EOI, and a peripheral decides to send a continuous interrupt request over its IRQ line. The 8259 will interrupt continuously, and you'll fill 64K of stack space pretty quickly, if you haven't crashed the machine entirely.

When should you use automatic EOI? On the PC, probably never. If you do, Intel suggests leaving interrupts disabled during all service routines. Then, on return from the routine (bear in mind that the IRET will reenable interrupts), the highest priority outstanding will be serviced first.

How does one go about changing the priority ordering of the 8259? There are several means to do this: automatic rotation, specific rotation, and the special mask mode. Let's take each in turn.

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	IRQ #	7	6	5	4	3	2	1	0
A	PRIORITY	7	6	5	4	3	2	1	0
	ISR	0	0	0	0	0	0	0	0
	IRQ #	7	6	5	4	3	2	1	0
B	PRIORITY	7	6	5	4	3	2	1	0
	ISR	0	0	0	0	0	1	0	0
	IRQ #	7	6	5	4	3	2	1	0
C	PRIORITY	4	3	2	1	0	7	6	5
	ISR	0	0	0	0	0	0	0	0

Figure 5: Effect of ROTATE ON NON-SPECIFIC EOI Command 5A: Pre-existing condition. 5B: Condition while servicing IRQ2. 5C: Condition after execution of command.

Automatic Rotation: Suppose you have a number of interrupt sources, all of which have equal priority. By necessity, each source is assigned to a specific IRQ line. Therefore, the sources attached to lower-numbered lines will have higher priorities. In a worst case scenario, the peripheral hooked to IRQ7, the lowest priority, may never get serviced, while IRQ0 has all the fun. The nice thing to do is to give everyone a fair shake by rotating priorities after each interrupt. There are a couple of ways to accomplish this.

The *rotate on non-specific EOI* command is a combination command that performs two functions. First, it resets the highest priority ISR bit currently set, just as does the simple non-specific EOI command. Second, it adjusts the priority ordering such that the interrupt channel just serviced is given the lowest priority. Figure 5 is an example of the effect of this. Suppose that the default condition is in effect: IRQ0 has the highest priority, and IRQ7 the lowest (5A). Now suppose that IRQ2 is activated and serviced (5B), and that the service routine concludes with a rotate on non-specific EOI command. The command will reset ISR bit 2, and then reorder the priorities to make IRQ2 the lowest priority (5C). If we assume that all of the peripherals are interrupting randomly, the effect of rotate on non-specific EOI will be to allow all sources to be serviced equally, regardless of the IRQ lines to which they are attached.

If you are in automatic EOI mode, you can additionally specify the *rotate in automatic EOI mode.* In this mode, a priority rotation will occur after each automatic EOI. This rotation is identical in function to the rotation occurring after the rotate on non-specific EOI command.

Specific rotation: Specific rotations allow the programmer to specify which interrupt channel has the lowest priority. There are again two ways to accomplish this.

The *set priority command* allows the programmer to tell the 8259 which IRQ line should be as-

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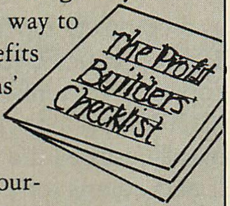

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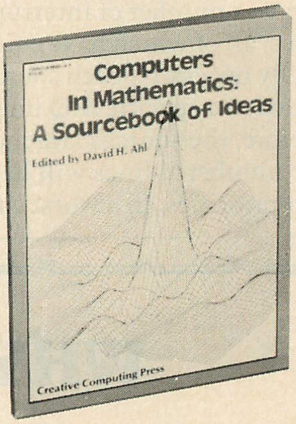

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		7	6	5	4	3	2	1	0
	IRQ #	7	6	5	4	3	2	1	0
A	**PRIORITY**	7	6	5	4	3	2	1	0
	IRQ #	7	6	5	4	3	2	1	0
B	**PRIORITY**	2	1	0	7	6	5	4	3

Figure 6: Effect of SET PRIORITY Command
6A: Pre-existing condition. 6B: Condition after execution of command specifying IRQ4 as low priority.

signed the lowest priority. Figure 6 is an example. In 6A, the default condition exists; 6B shows the status after the programmer has specified IRQ4 to be the new lowest priority. (Note that the priorities are in all cases ordered—we just specify who has the highest/lowest.) The program can issue this command at any time, either in the program mainline, or during a service routine.

There's at least one possible trap here for the unwary. Suppose that a) the default ordering exists, b) the routine for IRQ6 is executing, and c) the IRQ6 routine is then interrupted by IRQ2. Figure 7A illustrates the conditions. Now further suppose that the service routine for IRQ2 issues a set priority command causing IRQ2 to be assigned the lowest priority (7B). What happens if the IRQ2 routine concludes with a non-specific EOI? Because the command causes the highest priority ISR bit to be reset, ISR bit 6 will be cleared. It's the wrong bit. Best to use the specific EOI command at the end of any service routine that issues a set priority command.

	IRQ #	7	6	5	4	3	2	1	0
A	**PRIORITY**	7	6	5	4	3	2	1	0
	ISR	0	1	0	0	0	1	0	0
	IRQ #	7	6	5	4	3	2	1	0
B	**PRIORITY**	4	3	2	1	0	7	6	5
	ISR	0	1	0	0	0	1	0	0

Figure 7: Improper Use of Nonspecific EOI
7A: Service routines are currently running for IRQ6 and IRQ2. 7B: Condition after IRQ2 changes priority. Nonspecific EOI will reset bit 6 of ISR (wrong) instead of bit 2 (right).

set, and the corresponding IRQ channel is assigned the lowest priority.

Special Mask Mode: An interesting feature, the special mask mode allows the programmer to temporarily enable interrupts from levels lower in priority than those currently in service. Suppose, again, that the default ordering ex-

The second way to cause a specific rotation is to issue the *rotate on specific EOI command.* This command avoids the trap described in the last paragraph by combining two commands: set priority and specific EOI. When this command is issued, the specified ISR bit is re-

Figure 8: The Special Mask Mode

		7	6	5	4	3	2	1	0
A	**IRQ #**	7	6	5	4	3	2	1	0
A	**PRIORITY**	7	6	5	4	3	2	1	0
A	**ISR**	0	1	0	1	0	0	0	0
A	**IMR**	0	0	0	0	0	0	0	0
B	**IRQ #**	7	6	5	4	3	2	1	0
B	**PRIORITY**	7	6	5	4	3	2	1	0
B	**ISR**	0	1	0	1	0	0	0	0
B	**IMR**	0	1	0	1	0	0	0	0

ists, and that ISR bits 4 and 6 are set. Necessarily, this means that the IRQ6 routine was being executed when IRQ4 interrupted. IRQ4 service is now in progress. All interrupts are unmasked (Figure 8A). To enter the special mask mode, we would do two things: first, set IMR bits 4 and 6; second, issue the special mask mode command (8B).

What happens? IRQ0-3, IRQ5, and IRQ7 are enabled. In other words, all IRQs are enabled *except* those that are masked. This allows, say, IRQ5—a lower priority—to interrupt the currently executing IRQ4 service routine. Pursuing this further, you might ask why this is different from simply setting and/or resetting IMR bits. And why couldn't you accomplish the same thing by issuing an EOI command early in the IRQ4 service routine? Can you use a non-specific EOI command when in the special mask mode? Intel's documentation helps with the answers.

One final point on the subject: When does priority resolution occur? Suppose, for example, that priorities are normally ordered, that the service routine for IRQ0 is executing, and that an interrupt is pending for IRQ7. What happens if the IRQ0 routine issues a set priority command specifying IRQ4 as the new low priority? You can draw yourself a priority diagram which will show that IRQ7 (which is pending) now has a higher priority than IRQ0 (which is executing). Will the IRQ7 interrupt be asserted immediately? No. Priority resolution occurs only when a) an inter-

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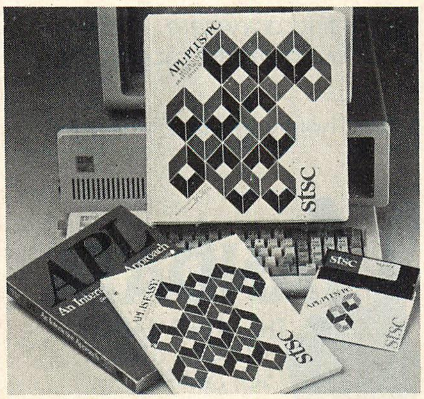

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rupt request is first received over an IRQ line from a peripheral, and b) the CPU acknowledges an interrupt request from the 8259.

Vectoring: Vectoring, the third of the four major categories of 8259 operation, is relatively uninvolved. When the CPU has acknowledged an 8259 interrupt request, the 8259 must return to the CPU an interrupt type number. This specifies where in the interrupt vector table the CPU should look for the service routine's address. Where does it get this number? It's simply an 8-bit number, whose first 5 bits are specified at initialization, and whose last 3 bits are the IRQ number to be serviced. In the PC, the 5 bits specified at initialization are 00001B. So if IRQ3 wants attention, the 8259 will construct the number starting with 00001B and ending with 011B (011 binary = 3 decimal). The result is 00001011B, or 11 decimal.

The CPU recognizes this as an interrupt type number, and multiplies it by 4 to find the absolute memory location where the service routine's address is stored. In this case, the IP portion is at location 44 (hex 0000:002C), and the CS at location 46 (hex 0000:002E).

By reinitializing the 8259, you can change the top 5 bits of the vector, but remember that the BIOS has set pointers to all of its own interrupt service routines, which must be copied into the new vector table.

Status Reporting to the CPU

The 8259 permits the programmer to ascertain the exact status of the interrupt system at any time. The contents of the three registers—IMR, IRR, and ISR—can be read, and a modified version of polling is supported.

The three register reads are straightforward (see the 8259 programming section), but the modified polling deserves a brief description. It allows use of a simplified polling mechanism to replace or augment the interrupt structure al-

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To employ polling, issue a *poll command* to the 8259, with processor interrupts disabled. Following this command, the 8259 will treat the next read pulse to the chip (i.e., the next INput instruction addressed to the 8259) as though it were an INTA pulse—an interrupt acknowledge. Thus, if there are any unserviced interrupt requests from peripherals, the highest priority of these will be considered to be in service, and its ISR bit will be set. The 8259 will then place a special status word on the system data bus (which the INput will read). Bit 7 of this word, if one, indicates that an interrupt request is present; if bit 7 is one, bits 0-2 contain the IRQ number of the interrupt to be serviced.

In other words, in the polling mode, the 8259 will give you the IRQ number of the highest priority interrupt request outstanding and will consider that request to be in service. Note that the interrupt vector is *not* specified by the 8259; it is up to the programmer to route execution to the appropriate service routine. In this way, no interrupt vector table is needed.

Before we turn to 8259 programming, a caution: IRQ0 and IRQ1 are both on the system board, while IRQ2-7 are in the I/O channel (i.e., available to each of the peripheral slots.) This means IRQ0-1 are permanently assigned to the system timer and keyboard, respectively, while IRQ2-7 are at the mercies of peripheral card designers. There is nothing sacred about IRQ6, for example. The diskette adapter is wired so that, when it asserts an interrupt, it uses the IRQ6 line. It could have been designed to use any of IRQ2-7. Any other card could also use IRQ6. We'll just have to assume that the peripheral card designers will try to make life easier by maintaining consistency.

8259 Programming—Initialization

The 8088 CPU programs the inter-

rupt controller by using OUTput instructions. That is, the 8259 is addressed by the 8088 as an I/O device; in the PC, it is located at ports 20H and 21H. Once again, following descriptions pertain only to the PC.

There are two general types of operation codes issued to the 8259: initialization control codes and operation control codes.

The initialization is a sequence of 3 bytes OUTput to the 8259. These bytes specify the chip's basic operating mode; they are called ICW1, ICW2, and ICW4 (*I*nitialization *C*ommand *W*ords; ICW3 is not used on the PC). The ICW's are illustrated in Figure 9. They work as follows:

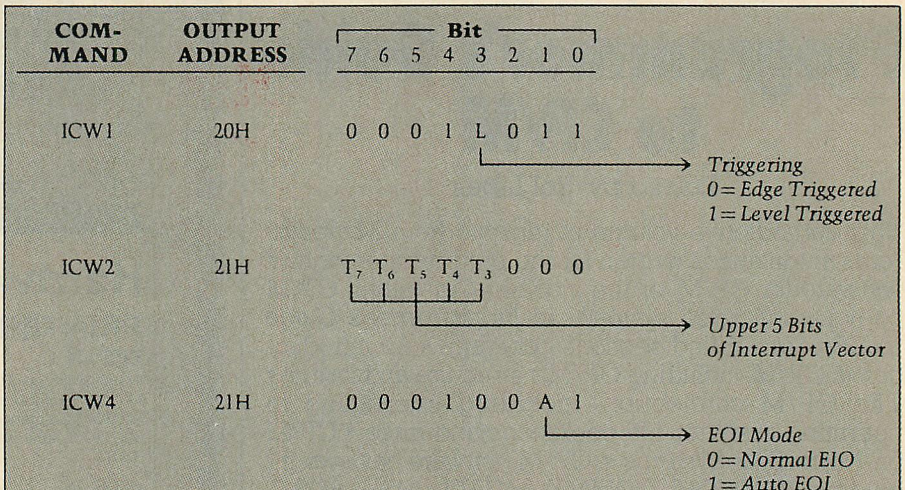

Figure 9: Initialization Command Words

ICW1: this byte (OUTput to port 20H) specifies the triggering mode. The only optional bit (bear in mind that this is true for the PC's configuration only) is the L bit; a one indicates level triggering, and a zero indicates edge triggering. To program the 8259's triggering mode, place 00010011B in register AL for edge, or 0011011B for level, triggering, and then execute an output instruction to port 20H. The standard mode for the PC (edge triggering) would be set up as follows:

MOV AL,00010011B OUT 20H,AL

ICW2: this byte (output to port 21H) partially specifies the interrupt type. The five T bits constitute the upper five bits of the interrupt vector supplied by the 8259 to the 8088 when an interrupt request is acknowledged. Refer back to the section on vectoring if this isn't clear. In the standard PC mode,

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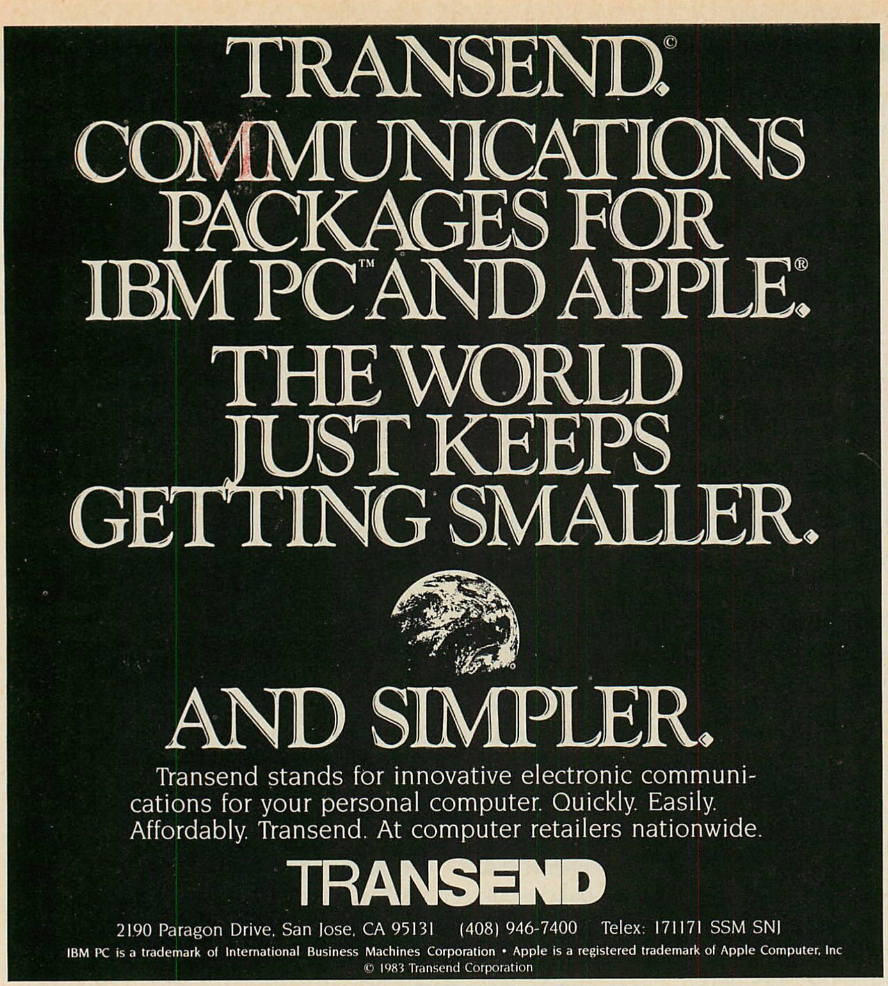

these five bits are 00001, so ICW2 is specified as

MOV AL,00001000B OUT 21H,AL

ICW4: the final initialization byte (output to port 21H) sets the EOI mode. A one in the A bit puts the 8259 into automatic EOI, and a zero indicates normal EOI. Move 00010001B to reg AL for normal EOI, or 00010011B for auto EOI, and then

OUT 21H,AL

That takes care of initializing the chip. You can reinitialize it any time you want by resending the sequence. You must, however, always send all three bytes in order: ICW1, ICW2, ICW4. Also, bear in mind that the following is done whenever the 8259 receives the initialization sequence:

1. The ISR is cleared to all zeroes.

2. The IMR is cleared to all zeroes.

3. The special mask mode is reset.

4. The rotate in automatic EOI mode is cleared.

5. The priority sequence is reset to default: IRQ0 has the highest priority, IRQ7 the lowest.

6. The edge sense latch is cleared for each IRQ input. This means that, if you select the edge triggered mode, a low-to-high transition on the IRQ lines must occur before an interrupt request will be generated.

7. The IRR is selected for register reads (see OCW3 below).

8259 Programming—Operations

After initialization, there are three operational controls which can be issued to the 8259 at any time. These are called OCW's (Operational Command Words), and they are illustrated in figure 10.

OCW1: This OCW is simply a link to the IMR (the mask register). Unlike the other OCW's, it has no prespecified bit record; its eight bits

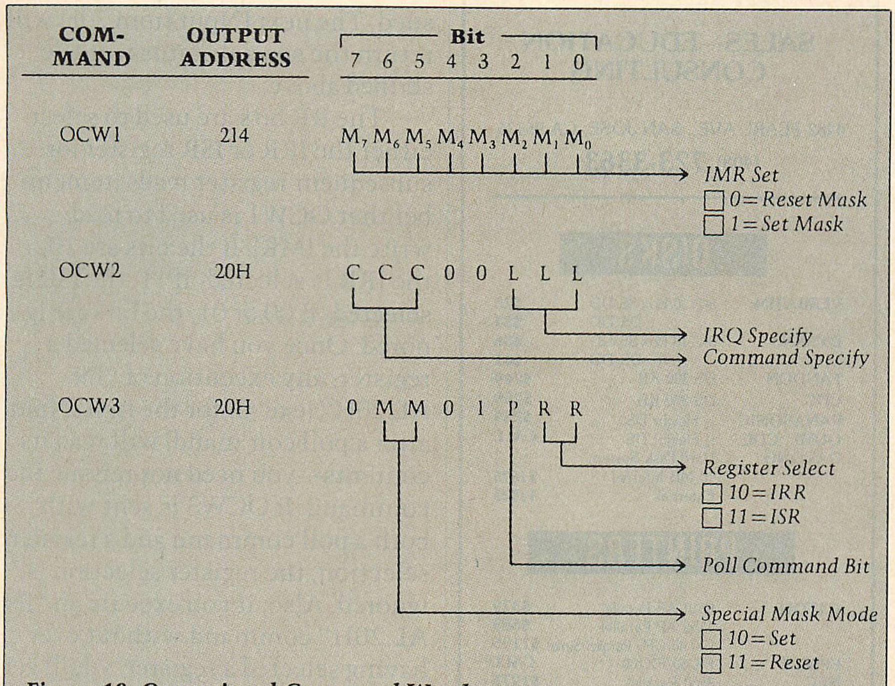

Figure 10: Operational Command Words

correspond directly to the bits of the IMR. To write the contents of the IMR, simply use the command

OUT 21H,AL

where register AL contains the bit pattern you want written to the IMR. For example, if you want to mask IRQ0 (the system timer), use the following code:

MOV AL,00000001B OUT 21H,AL

OCW2: This command (OUTput to port 20H) is used to modify priorities and to send EOI signals to the 8259. The three CCC bits specify which command is being sent. In cases where the command requires that an IR2 number be specified. (The three commands marked with asterisks in Figure 11), the LLL bits are used for that purpose. The CCC and LLL decode is shown in Figure 11.

A couple of examples to clarify OCW2:

1. Send a non-specific EOI to the 8259. (This is what you normally would do at the end of an interrupt service routine.) The CCC bits for non-specific EOI are 001; since non-specific EOI does not require that an IRQ be named, the LLL bits are "don't cares." So the code for a normal EOI is

MOV AL,00100000B OUT 20H,AL

2. Send a specific EOI command, clearing ISR bit 7. The CCC bits for specific EOI are 011. In this case, an interrupt level must be named, so the LLL bits are used. To specify bit 7, LLL will be 111:

MOV AL,01100111B OUT 20H,AL

3. Modify priority sequence, giving IRQ4 the lowest priority. The CCC bits for set priority are 110, and 100 will specify IRQ4:

MOV AL,11000100B OUT 20H,AL

OCW3: The last operational command word is used to read the ISR and IRR registers, to issue the poll command, and to set/reset the special mask mode. It is output to port 20H.

The two MM bits are used to set/reset the special mask mode. If the bits are 10, the special mask mode is reset; if they are 11, the mode is set; if they are 00 or 01, the bits are ignored.

The P bit is the poll command bit. If it is 1, the poll command is is-

sued. The next INput from 20H will return the special status word described above.

The RR bits are used to select either the IRR or ISR register for subsequent register reads (remember that OCW1 is used to read/write the IMR). If the bits are 10, the IRR is selected; if 11, the ISR is selected; if 00 or 01, the bits are ignored. Once you have selected a register, any execution of "IN AL,20H" (except for the first INput after a poll command) will read its contents—you need not reissue the command. If OCW3 is sent with both a poll command and a register selection, the register selection is ignored. Also, if you execute an "IN AL,20H" command without ever having selected a register, you'll get the IRR.

Here are some examples:

1. Select the ISR register for subsequent reads:

MOV AL,00001011B OUT 20H,AL

2. Select the IRR register for subsequent reads:

MOV AL,00001010B OUT 20H,AL

3. Read the reg selected via example 1 or 2:

IN AL,20H

4. Issue the poll command and read the results:

MOV AL,00001100B OUT 20H,AL
IN AL,20H

5. Set the special mask mode:

MOV AL,01101000B OUT 20H,AL

6. Reset the special mask mode:

MOV AL,01001000B OUT 20H,AL

CONCLUSION

That's about everything you need to know regarding the 8259A Programmable Interrupt Controller. I do want to stress that I have not attempted to cover all of its features, and that I have also simplified some of its operations. If you are interested in an in-depth discussion of the chip, read the Intel AP-59 note mentioned in the references. It's ex-

```
7 6 5 4 3 2 1 0
C C C X X L L L
```

000 = Clear rotate in auto-EOI mode
001 = Nonspecific EOI command
010 = No operation
011 = Specific EOI command*
100 = Set rotate in auto-EOI mode
101 = Rotate on nonspecific EOI command
110 = Set priority command*
111 = Rotate on specific EOI command*

000 = IRQ0
001 = IRQ1
010 = IRQ2
011 = IRQ3
100 = IRQ4
101 = IRQ5
110 = IRQ6
111 = IRQ7

Figure 11: OCW3 Decoding. Commands without asterisks ignore LLL bits.

cellent, and is the source of virtually everything you have read above.

In Part II, we'll put into practice some of the things that were covered herein.

REFERENCES

1. *Technical Reference.* IBM Corporation, P. O. Box 1328, Boca Raton, Florida 33432.

2. *iAPX 86,88 User's Manual.* Intel Corporation, Literature Department SV3-3, 3065 Bowers Avenue, Santa Clara, California 95051.

3. "Using the 8259A Programmable Interrupt Controller". Application Note AP-59, Intel Corporation (available separately or included in *User's Manual*).

Chris Dunford is an independent consultant specializing in financial applications and technical services for personal computers in business.

QUIZ TIME!

Now that we've covered quite a bit of the interrupt structure of the PC, let's take a look at an annoying problem in DOS's DEBUG program. It's a problem that involves the interrupt system.

You may have noticed that DEBUG occasionally goes into outer space during the Trace operation (single-stepping). The symptom is a register display which shows an execution address that has nothing to do with the program you are debugging, followed by a refusal to accept any keyboard input. It's necessary to reboot the machine to regain control.

The problem has to do with an error in interrupt handling during single stepping. If the system clock (via the 8259) causes INTR to go active while an instruction is executing with the trap (single step) flag set, the 8088 will acknowledge the interrupt request. The flags and CS:IP are pushed onto the stack, interrupts are disabled, and the CS:IP values for the timer service routine are loaded from the vector table. At this point, *before the timer service routine is executed,* the CPU recognizes the single step interrupt. The flags and CS:IP are pushed again, and DEBUG's single step service routine is executed. The routine enables interrupts, displays the register contents (getting CS:IP from the stack!), and waits for the next user command.

Three questions: why can't DEBUG get anything from the keyboard? What should DEBUG have done before executing the single-stepped instruction? What can you do to partially remedy the problem WITHOUT PATCHING DEBUG? You have 15 seconds...begin.

Ready? First answer: DEBUG can't get input because ISR bit 0 is set. The keyboard is wired to IRQ1, which has a lower priority, so the 8259 won't pass along a keyboard interrupt request. Second answer: DEBUG could have avoided the problem with one additional byte—a CLI instruction executed just before single stepping. Third answer: before executing DEBUG, rotate priorities so that IRQ0 has the lowest priority. If the error situation occurs, the clock will get no further service, the CS:IP values in the register display will be wrong, and there will be six extra bytes on the stack, but at least the keyboard won't be dead. I did say it was a partial fix...

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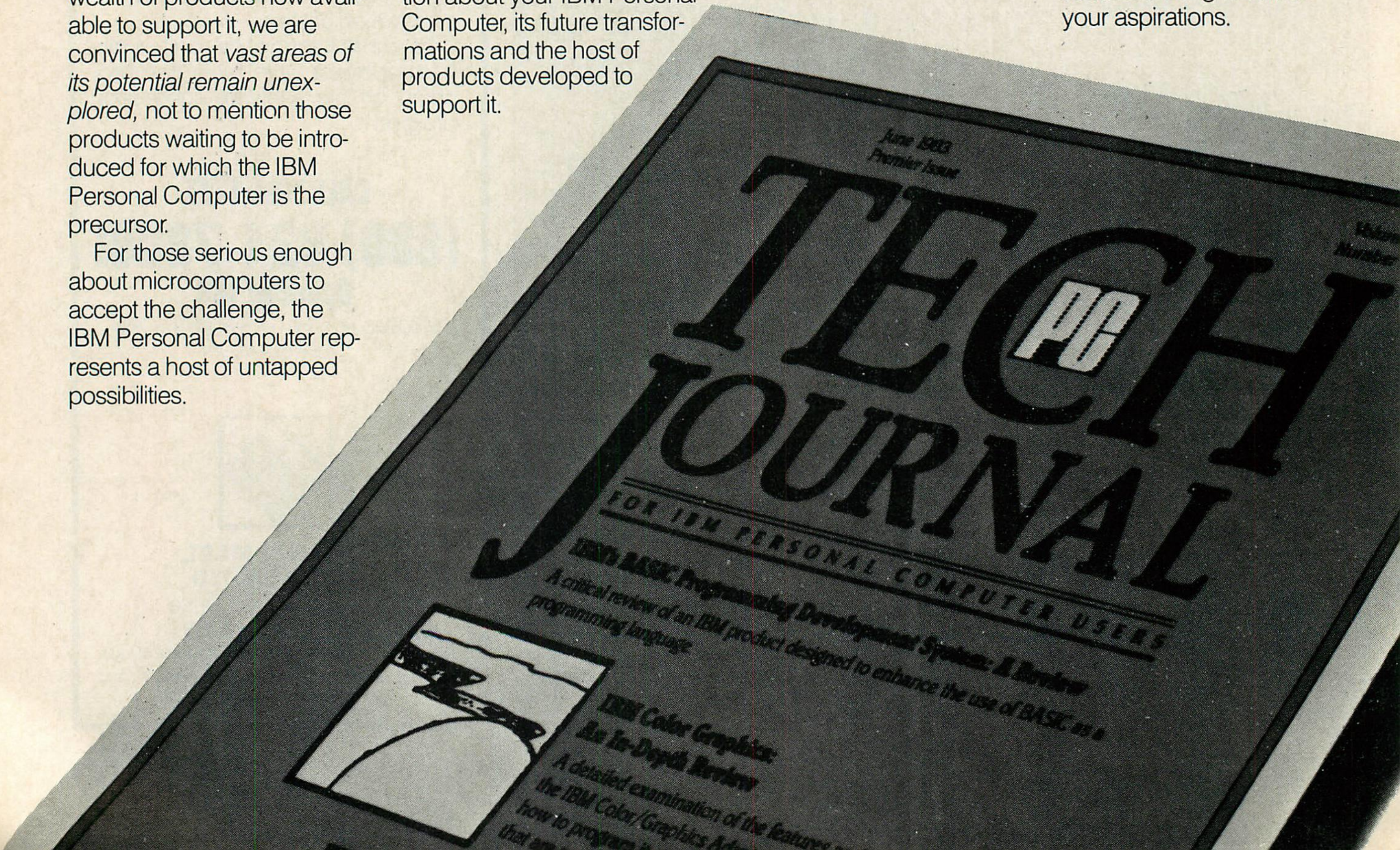

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TECH NOTEBOOK 9

Filename Extensions

A useful reference for the most commonly used filename extensions in PC-DOS

ARTHUR A. GLECKLER

In PC-DOS, a large number of filename extensions have become standard and widely used. Software developers and users alike should be aware of these conventions in order to avoid confusion and conflict. Here is a list of some of the most commonly used extensions:

$$$	DOS 2.0 %PIPE# file; used by DOS 2.0 to send the output of one program to be used as input for another program; can be seen by typing dir:dir in the root directory
AIO	APL file transfer format
APL	APL workspace format
ARF	Automatic response file used by IBM's BASIC, COBOL, and FORTRAN compilers; similar in usage to batch file
ASM	Assembly language source code (in ASCII format) to be used by the IBM MacroAssembler
BAK	Backup file for edlin (in ASCII format); edlin renames original file to filename.BAK, then saves the edited file under the old name
BAS	BASIC language program; may be in ASCII format with Ctrl-Z terminator or in BASIC special format
BAT	Batch (job control language) file; in ASCII format
BIN	Binary format file; used to store exact memory images
CAL	SuperCalc spreadsheet datafile format
CHK	File produced by CHKDSK/f when problems with a disk are found and user requests an attempt at recovery of lost information. .CHK files are the recovered information.
CMD	dBase II command file
COB	COBOL source program
COD	Compiled assembly code source listing file from the IBM FORTRAN and Pascal compilers
COL	MultiPlan spreadsheet datafile format
COM	Machine language programs and non-resident DOS commands
CRF	Cross-reference information generated by the IBM MacroAssembler for use by a cross-reference utility
DAT	Program data
DBF	Database file from dBase II
DEV	Device file - in DOS 2.0 CONFIG.SYS file
DIF	VisiCalc data interchange format
EXE	Executable, relocatable code produced by LINK
FOR	Fortran source program
FRM	dBase II report form files
HEX	Causes DEBUG to treat a file as an ASCII file of hexadecimal numbers and convert the numbers to binary as it loads them
HLP	Help information file
IMP	Implementation files for IBM Pascal units
INT	Interface files for IBM Pascal units
LIB	Library file; used by the linker to locate library module files
LST	Program listing generated by an the IBM MacroAssembler; similar to source (.ASM) listing, but includes assembled code in hexadecimal notation, etc.; in ASCII format
MAP	Default extension for list file created by LINK
MEM	dBase II memory file
MSG	MultiPlan message file
NDX	dBase II index file
OBJ	Object code modules produced by compilers and assemblers and used as input to the linker
OVL	Program segment created by the linker when linking a segmented program
OVR	Overlay file
PAS	Pascal source program
PRF	VisiCalc print format
PRG	dBase II program file (same as .CMD files in CP/M)
REF	Printable cross-reference listing generated by a cross–reference utility using information in .CRF file
SYS	DOS System file; used for CONFIG.SYS system configuration file
TMP	Temporary file
TXT	ASCII text files, sometimes used for ASCII output from a word processor
VC	VisiCalc normal spreadsheet datafile format

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OMNIMICRO is $28,000 for DOS systems and $35,000 for OS systems.

ON-LINE SOFTWARE INTERANTIONAL
Fort Lee Executive Park
Two Executive Drive
Fort Lee, NJ 07024.
800-526-0272 or in New Jersey 201-592-0009.

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mbp Software and Systems Technology, Inc. has added compatibility with PC-DOS 2.0 and IBM PC and XT to its COBOL Compiler. The new version gives COBOL programmers increased execution performance by generating native machine language object code. The ANSI '74 Level II mbp COBOL also offers multi-keyed ISAM, Dynamic Assign options, and numerous extensions to the COBOL standard. $500.

mbp SOFTWARE AND SYSTEMS TECHNOLOGY, INC.
7700 Edgewater Dr.
Suite 360
Oakland, CA 94621.
415-632-1555.

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Electronic Circuit Analysis (ECA) from Westico, the Software Express Service, may be of interest to science and engineering fields. It can analyze circuits of up to 64 nodes and 127 branches. For electrical engineers it is an alternative to bread boarding, testing, and measuring for the design of new electronic circuits. It is available for CP/M-80, MS DOS and PC DOS-compatible computers. $150.

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A Pascal compiler, SBB Pascal™, is the first product to be released by **Software Building Blocks, Inc.,** of Ithaca, NY. SBB Pascal is a two-pass, locally optimizing Pascal compiler for the IBM PC. The compiler package includes an interactive Pascal debugger, written in SBB Pascal, designed to aid in isolating and correcting faults in Pascal programs. $4350.

SOFTWARE BUILDING BLOCKS, INC.
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607-272-2807

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VMPC
60 East 42nd Street
New York, NY 10165
212-637-4747
Outside New York State call 800-847-3529

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Context Management Systems now has Version 2 of its Context MBA software package, and it runs on all versions of the IBM PC, including the XT. The new program combines telecommunications, business graphics, financial analysis, word processing, data management and custom forms design into a single integrated software package. Context is providing Version 1 owners with a new package at no extra cost. $695.

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Los Angeles, CA 90067
213-557-1331

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INNOVATIVE SOFTWARE, INC.
9300 W. 110th Street
Suite 380
Overland Park, KS 66210
913-383-1089

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Taurus Software Corp. now has its CP+ for the PC. CP+ is actually three products: a computer-aided instruction tutorial on the basic operations of a personal computer; an English-language front-end interface suitable for novice or non-technical users, and a package of file management utilities. Version 2.0 of CP+ is a smaller, faster implementation of the product with several new features including START+, which allows the dealer, OEM, or end-user to integrate a major application package through a customizable menu screen. $200/ 16-bit version; $150 for 8-bit version.

TAURUS SOFTWARE CORP.
3865 Mt. Diablo Blvd.
Lafayette, CA 94549
415-283-7222

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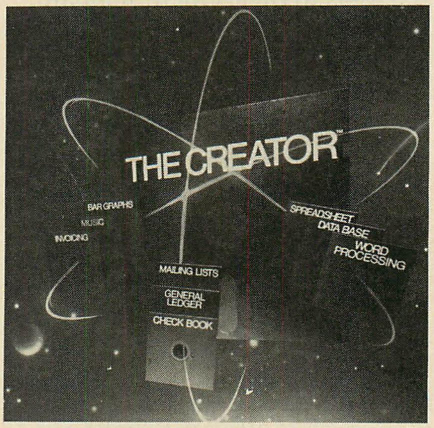

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MAG/base from MAG Software, Inc., is now available for the IBM PC. MAG/base is data management software that comes in three versions in varying degrees of sophistication. All three provide up to 99 keys, 999 fields per record, and up to 999,999 records per file. User memory required is 128K with two

double-sided diskettes or a hard disk. $295, $495, and $795.

MAG SOFTWARE INC.
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Canoga Park, CA 91303
213-883-3267

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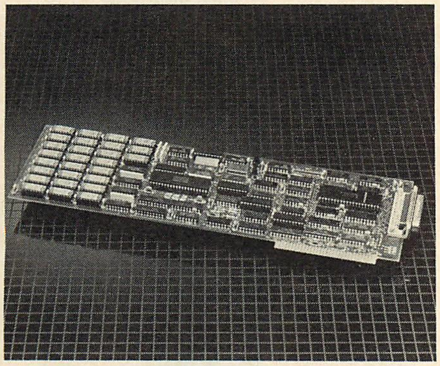
Hardware

California Computer Systems' new Z-80 processor board enables PC users to execute CP/M 2.2 or CP/M 3.0 programs. It has a 6MHz Z80B microprocessor, up to 192K bytes of dual-ported memory, and an asynchronous communications interface. When the Z80 is not in use, the memory may be used by the 8088 processor in the PC. Parity is supported properly by both the Z80 and the 8088. The asynchronous communications port may be con-



figured as either COM1 or COM2. Using CP/M 2.2, 64K bytes of memory are supported; using CP/M 3.0, 192K are available.

CALIFORNIA COMPUTER SYSTEMS (CCS)
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408-734-5811

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Version 1.07 of the Blue Lynx 3276 SNA/SDLC micro/mainframe communications link from Techland uploads and downloads data from the PC or XT to the 4341, 3033, and 3081. The new version features a configuration routine that simplifies installation and a completely revised instruction manual. With Blue Lynx the PC or XT can be a stand-alone distributed processor and an on-line terminal. The Blue Lynx board slips into a slot in the PC or XT and connects via modems and phone line to the host. $690.

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AST-5251, also $895, allows a PC to be connected to the IBM System/34 or IBM System/38 for interactive communications.

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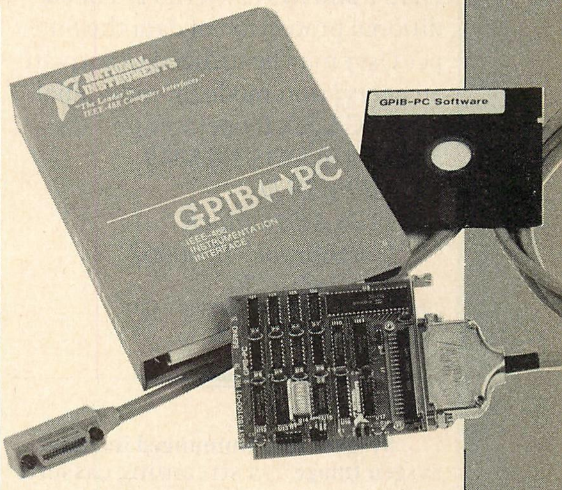


National Instruments now makes an IEEE-488 interface that converts the IBM PC into an instrumentation workstation complete with software. The GPIB-PC software consists of a handler under PC DOS 2.0 and subroutines that may be called from an application program witten in BASIC, 8088 assembly, Pascal, FORTRAN, or C. The GPIB-PC circuit card is implemented with the NEC 7210 GPIB controller chip and a Programmable Array Logic chip. $385 per single unit; OEM discounts available.

NATIONAL INSTRUMENTS
12109 Technology Blvd.
Austin, TX 78759
800-531-5066

CIRCLE 484 ON READER SERVICE CARD

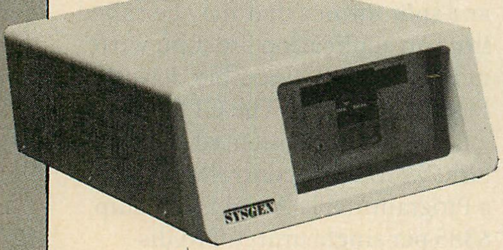
MPPi, Ltd. has released PC Lock II, its second generation of security products for the PC and XT. It is a combination of a 5-by-4 printed circuit board and a software diskette called a Super User, which allows the PC user the control to place files under password protection. Up to 42 passwords may be utilized with hierarchical levels of access, i.e., READ

ONLY and READ/WRITE. For additional protection of data the Super User may be utilized to activate an encryption mode for individual files. PC Lock II operates on PCs and XTs in DOS 2.0 $349.

MPPi. LTD.
1126 Adirondack
Northbrook, IL 60062
312-480-9730

CIRCLE 485 ON READER SERVICE CARD

Sysgen, Inc. announced its new Sysgen Image™, a streaming cassette tape backup for the XT. The backup subsystem includes controller, drive electronics, and tape drive. It is software compatible with either PC-DOS or CP/M-86. Under software control, the Image will per-



form complete archival backup of information on a hard disk at the rate of up to 2.5M bytes per minute. Storage capacity of the streaming tape cassette in the Sysgen Image is 20M bytes. $995.

SYSGEN INC.
47853 Warm Springs Blvd.
Fremont, CA 94539
415-490-6770

CIRCLE 486 ON READER SERVICE CARD

Linkup™ from Information Technologies Inc. is a comprehensive communications package for the PC. Its nucleus is a programmable hardware module that supports industry standard protocols and emulates commercially available terminals at data rates up to 56K. Initial Linkup software options will support TTY, DEC VT52/100, IBM 3101, IBM 2780/3780 emulation, ASCII Block Protocol and a print spooler.

INFORMATION TECHNOLOGIES, INC.
7850 East Evans Road
Scottsdale, AZ
602-998-1033

CIRCLE 487 ON READER SERVICE CARD

RTA 331 from Ariel is a ⅓ octave audio frequency spectrum analyzer that plugs into a single expansion slot inside the PC. The Analyzer divides the audio spectrum into 31 third-octave bands from 20 Hertz to 20 kHertz and interactively displays the relative amplitude of each frequency band. $649.95.

ARIEL CORPORATION
600 West 116th St.
New York, NY 10027
212-662-7324

CIRCLE 488 ON READER SERVICE CARD

From NETWORX™ comes the Wire Tree™, a reliable protection against voltage surges, spikes, and radio frequency interference (RFI) that can damage circuitry and affect computer memory. It mounts on the computer work station and offers continuous protection through surge-limiting, solid-state circuitry built into four grounded outlets. The circuitry absorbs any dangerous spike energy before it reaches the computer by providing an extremely rapid decrease in circuit impedance. The Wire Tree organizes the nine-foot power cord and four peripheral power cords to one side and drapes them to the rear of the workstation. $69.95.

NETWORK
203 Harrison Place
Brooklyn, NY 11237
212-821-7555

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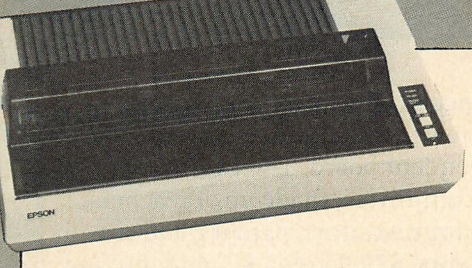

Epson's FX-100 dot matrix printer prints at 160 characters per second and 136 characters per line. It includes a choice of elite or pica spacing, and users can create their own character formats on the screen and download the font into the user's memory. $895.

EPSON AMERICA INC.
3415 Kashiwa St.
Torrance, CA 90505
213-539-9140

CIRCLE 490 ON READER SERVICE CARD

Companies

Control Data Corporation has acquired a license from **Chang Laboratories, Inc.** to market business software products for personal computers. Chang Labs produces numerous business software modules, including word-processing, financial planning, graphics, and others. The company's MicroPlan software, a financial planning spreadsheet, has already sold more than 100,000 copies.

CONTROL DATA CORPORATION
8100 34th Ave. South
Minneapolis MN 55440
612-853-6605

CIRCLE 491 ON READER SERVICE CARD

From ComputerLand Corporation comes news of its new national credit plan with **Citibank, N.A.** Card-carrying customers of ComputerLand's 300 franchised stores who want to finance an initial purchase of $1,500 or more will receive a revolving loan account.

The company has also opened its first **ComputerLand Learning Center,** in Indianapolis, the first of many such teaching centers nationwide.

COMPUTERLAND
30985 Santana Street
Hayward, CA 94544
415-487-5000

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Sensor-Based Systems has been approved by **IBM** as a value-added dealer (VAD) for the PC, which allows SbS to sell the PC and the XT with its added value component, **METAFILE**. In addition to a fourth generation language for application programming, METAFILE includes the facilities of data base management, report generation, word processing, decision support, and communications.

SENSOR-BASED SYSTEMS
Olmsted Federal Bldg.
Chatfield, MN 55923
507-867-4440

CIRCLE 493 ON READER SERVICE CARD

CENTEC CORP. and GENIGRAPHICS Corp. have signed a long-term marketing and technical agreement. The first phase of the development project will interface the CENTEC CHEETAH software system, operating on the IBM PC with the GENIGRAPHICS high-resolution film recorder. GENIGRAPHICS will market the CENTEC IBM PC containing the graphics interface to the GENIGRAPHICS film recorder, which allows users to create title and word slides, rectangular charts, pie charts, block diagrams, organization charts or pictorials.

CENTEC CORP.
11260 Roger Bacon Dr.
Reston, VA 22090
703-471-6300

CIRCLE 494 ON READER SERVICE CARD

VisiCorp has acquired Communications Solutions, Inc. (CSI), supplier of communications consulting services, educational and training programs and communications software that operates in the IBM Systems Network Architecture environment. CSI's ACCESS/SNA™ software product enables independent computer and terminal manufacturers to offer their products with full SNA-compatibility. And CSI software provides capabilities enhancements for the IBM PC user through its SNA 3270 emulation product. This feature permits the PC to operate as an IBM 3274 Control Unit for application in single or multiple workstation configurations.

The SNA technology skills and resources offered by CSI will enable VisiCorp to enhance the value of its recently announced VisiON software environment by combining the communications capabilities of ACCESS/SNA with the performance and flexibility of the VisiON product.

VisiCorp has also upgraded its

VisiSeries™ for the IBM PC and XT. Products upgraded include VisiCalc®, VisiTrend/Plot®, VisiFile™, VisiWord™, and VisiSpell™. VisiSchedule™ will be available in the fourth quarter. The software is being sold on single-sided, single-density diskettes so that they can be used on any IBM PC with or without a hard disk option, or with the XT.

VISICORP
2895 Zanker Road
San Jose, CA 95134
408-946-9000

CIRCLE 495 ON READER SERVICE CARD

Digital Research and Phaser Systems have entered a marketing agreement to share marketing and distribution rights for the micro/SPF™ products from Phaser. DRI will incorporate the Phaser System product line into its own, expanding the DRI Language Division family of productivity tools for microcomputers. Digital Research will make these products available under the DRI label both through its well-established retail distribution channels and through its OEM sales force.

Micro/SPF offers the professional programmer a structured development tool including a full screen editor with the following options: browse, edit, utilities, and a tutorial for on-line operating information. 3270/SPF allows a microcomputer to function as a TSO/SPF distributed workstation with local computing power via Digital Research's CP/M.

DIGITAL RESEARCH
P.O. Box 579
Pacific Grove, CA 93950
408-649-3896

CIRCLE 496 ON READER SERVICE CARD

TRAINING

Micro Learning Concepts, Inc. has a new 56-minute video tape designed to demystify personal computers. In five parts, "Learning Concept: Introduction to Personal Computers," illumines computer jargon; components and functions of personal computers; spreadsheet, word processing, and data base applications; computer graphics; and communications. Included with the tape is a 28-page Quick Reference Guide that offers an in-depth discussion of computer programming and programs.

Intended as an introduction for those who have just purchased or intend to purchase a computer, the tape is the latest in a series of video learning aids produced by Micro Learning Concepts to advance computer literacy. $99.95.

MICRO LEARNING CONCEPTS, INC.
380 Lexington Ave.
Suite 1208
New York, NY 10017
212-687-0066

CIRCLE 497 ON READER SERVICE CARD

PUBLICATIONS

Software Reports, a reference manual published by **Allenbach Industries, Inc.,** evaluates 382 educational software programs for five popular computer brands: Apple, Atari, Commodore, IBM-PC, and TRS-80. Programs for students in preschool through college were evaluated, as well as educational software for adults, school administrators, and special education students. Reviews are coordinated by an independent board, The Evaluation Committee, made up of teachers, administrators, parents, and students. $39.95 plus $3. shipping and handling.

ALLENBACH INDUSTRIES, INC.
2101 Las Palmas Drive
Carlsbad, CA 92008
800-854-1515
In California, call
619-438-2258, collect

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The **Journal of Pascal and Ada,** a bimonthly publication for Pascal, Modula-2, and Ada programmers, now covers Modula-2. Each issue contains a column dedicated solely to Modula, as well as feature articles on this small but powerful language. $14/yr.

WEST PUBLISHING
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Supertabs from Siechert & Wood Technical Publications are a set of mylar-reinforced dividers that summarize each section of the BASIC and DOS manuals, providing more complete information than is available with quick reference cards. SuperTabs come in two versions—DOS 1.0/1.0 and DOS 2.0 $9.95.

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Lattice - strong competitor, MS -REL	500	**395**
Manx - full - good to learn with	249	**215**
MicroSoft - decent, not what you'd think	500	**395**
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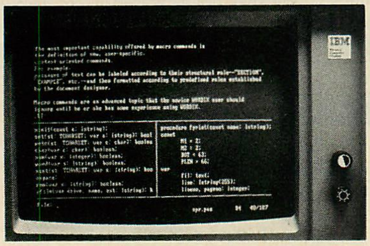

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All of the code produced is in BASIC. It can be compiled as-is, and it can be modified, if desired. Priced at $150.00 each, $350 for three.

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800-845-7594 or 803-574-4950

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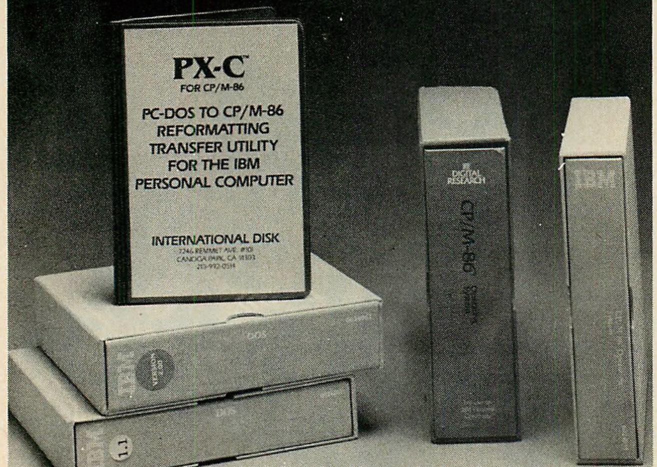

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The Basic Tools of U.S. Intellectual Property Law

An introduction to some elementary concepts of this law —with the help of a program.

Max Stul Oppenheimer

If you are like most microcomputer owners, some day you will write a program that is so powerful, so elegant and so universally necessary that in return for a fair share of the world's supply of money you will begin to think about making its benefits available to the entire world.

If you are like most beginning entrepreneurs, listing 1, which follows this article, is as close as you will come to a consultation with a lawyer until you are up to your HIMEM in trouble. Run it if you like. (It's okay. You have my permission and I have the copyright.) It may not be the most exciting video game you have ever played, but it will introduce you to some elementary concepts of what is known as intellectual property law.

Protection of computer software is one of the major trouble spots in that area of the law. The American Bar Association's Section on Science and Technology is currently examining the deficiencies of the existing system, but the process of a major revision of a complicated area of law is likely to be lengthy. In the meantime, it will probably be worth your while to become at least generally familiar with the basic tools of United States intellectual property law. Figure 1 introduces the central characters.

A federal copyright is secured automatically as soon as a copyrightable work is created. At this very moment Section 302(a) of Title 17 of the U.S. Code is creating a federal copyright just as fast as I can write. Nevertheless, it is a good idea to put a copyright notice on the finished product. It is easy and inexpensive to take the further step of registering a copyright claim, which provides several benefits, including establishing a public record of your claim. You can get the necessary forms and instructions from the Register of Copyrights, Library of Congress, Washington, DC 20559. A federal copyright gives the owner the right to prevent others from copying the work. Copyright protects artistic expression, not ideas—one of the reasons that there are many spread sheet programs and data base programs. Because there are many ways to instruct a computer to accomplish the same results, copyright is not a perfect tool for protecting software: a programmer can, without violating a copyright, use the underlying concepts he learned from another programmer's work provided he expresses them sufficiently differently. A copyright owner's remedies for infringement can, however,

Max Stul Oppenheimer is a practicing attorney and a regular contributor to this magazine.

be significant and include the right to obtain a court order impounding infringing copies and to recover the infringer's profits.

Generally, U.S. Patent gives the owner the right to prevent others from using the covered invention for a period of 17 years. While a copyright protects only the author's particular artistic expression of a concept, a utility patent protects the patented invention regardless of what form it takes. Patents, however, are considerably more expensive and difficult to obtain than copyrights. While copyrights are rou-

A software author would like the breadth of protection of the patent system with the simplicity and economy of the copyright system. I would like a System 38 with the price tag of a pocket calculator.

tinely registered upon the filing of an application, patents are issued only after an examiner determines that the application meets certain statutory criteria (including the requirement that there be an advance over the state-of-the-art). The examination process usually involves several rounds in which the examiner and applicant spar over the scope of the patent claims.

A software author would like the breadth of protection of the patent system with the simplicity and economy of the copyright system. I would like a System 38 with the price tag of a pocket calculator. While we're waiting, let's go on to trademarks.

Trademarks technically are not

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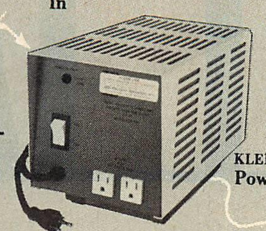

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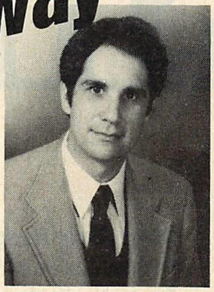

says Q-PRO 4 user,
Richard Pedrelli, President
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"As a dBASE II beta test site the past two years, we were reluctant to even try Q-PRO 4. Now we write all our commercial applications in Q-PRO 4. We find it to be an order of magnitude more powerful than dBASE II.

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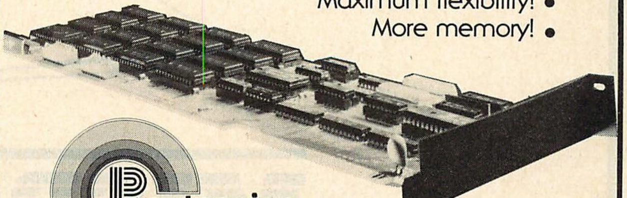

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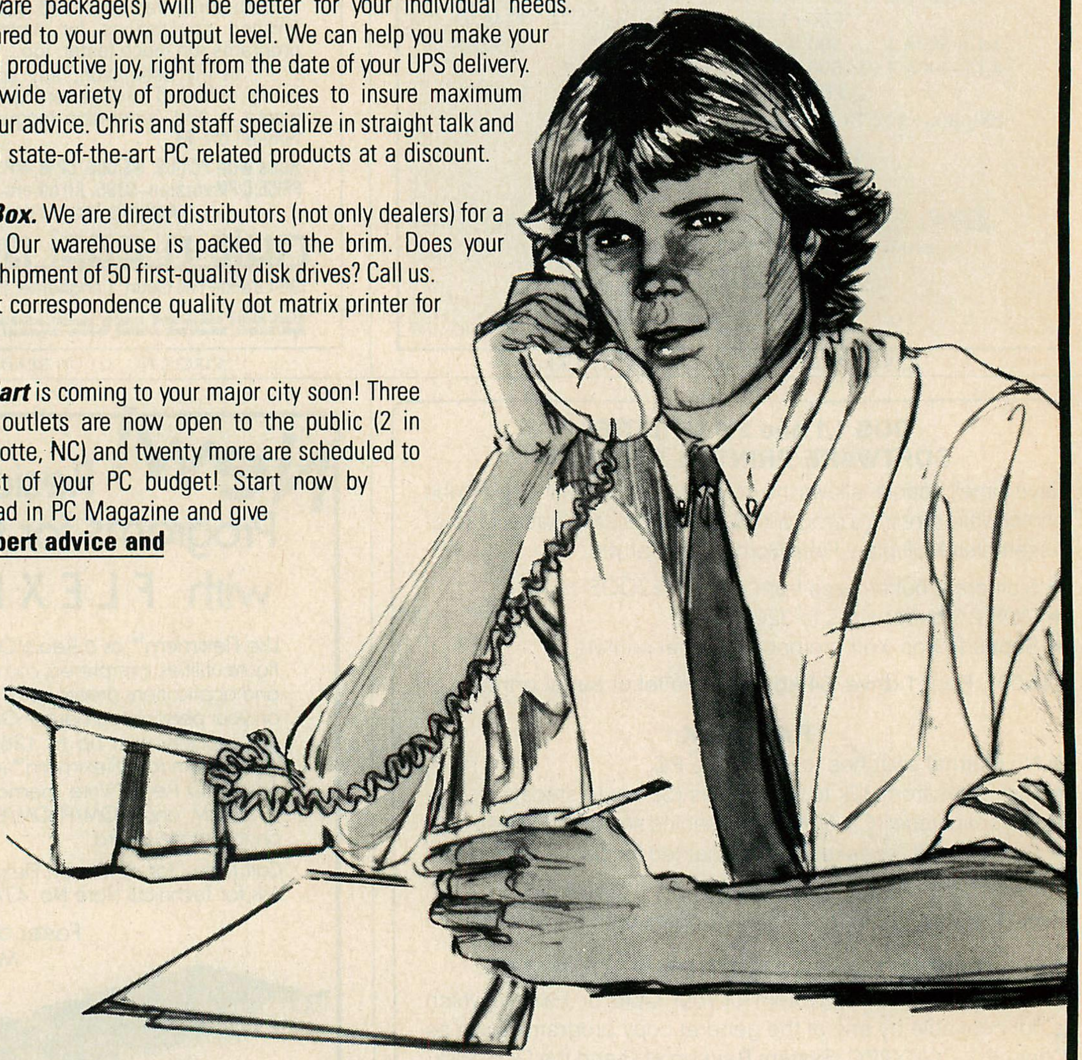

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intended to protect artistic expression or invention, but they can be extremely useful in protecting the

In the case of a custom program designed specifically for a limited number of users where the author can negotiate and enforce a secrecy agreement, maintaining a trade secret may be a viable option. It is cheap and foolproof—until the secret gets out.

value of software. A trademark protects the use of an identifying word or symbol in a particular field and geographic area (which may be nationwide). How does that help a software author? Well, suppose you could put any three uppercase English letters you wanted on the package containing your program. (The answer will be supplied to anyone sending a self-addressed stamped envelope to the editor). A trademark is acquired by use in connection with a product (or service, in which case it is referred to as a service mark). No registration is required, but coverage is limited to the geographic area (plus an additional area for expansion, which depends on the circumstances) in which the mark has been used to a substantial extent. There is a federal trademark statute that permits claimants to register under a procedure somewhere between copyright and patent in terms of complexity and cost. The key requirement is to demonstrate use of the mark in interstate or foreign commerce. The key benefit is the creation of constructive, nationwide notice of the trademark owner's claim.

The absence of a tailor-made method of legally protecting software makes trade secrecy appear to be an attractive alternative. Generally, trade secrecy protection is recognized where the owner has information that is not known to his competitors, that gives him a competitive advantage, and that he keeps secret. In the case of a custom program designed specifically for a limited number of users, where the author can negotiate and enforce a secrecy agreement, maintaining a trade secret may be a viable option. It is cheap and foolproof—until the secret gets out. In the case of a mass-marketed program where there is no direct negotiation between author and user, the author usually attempts to make secrecy self-executing (for example, by including instructions at the beginning of a program redefining the reset vector to erase the resident program from memory). The method is still cheap, but with the greater number of copies on the market and the absence of the moral sense of obligation to preserve secrecy

Figure 1: Central Characters of Intellectual Property Law

SYMBOL	MEANING	PRIMARY JURISDICTION
©	*Copyright*	*Federal (statute)*
Pat.	*Patent*	*Federal (statute)*
Pat. Pending *Pat. Applied for*	*An application for a patent has been filed, but the patent has not yet been issued*	
®	*Trademark (or Service Mark)*	*Federal (statute)*
TM	*Trademark is claimed, but federal registration has not yet been obtained*	*State (Common Law)*
[none]	*Trade Secret*	*State (Common Law)*

that may be imposed by face to face negotiations, the likelihood that the secret will get out rises and the ultimate value of trade secret protection is dramatically reduced. Once the secret is out, the chance of obtaining alternative protection is vanishingly small.

You now know the tools at your disposal. How to use them depends very much on the particular situation. Some factors to consider:

- Why is your program valuable? Is it a particular artistic feature or is it a clever concept? Once another skilled programmer has seen the output, how hard will it be for him to reproduce the end result using a different graphic representation or programming method.

How aggressive are you willing to be in pursuing infringers? Would you really sue the class of fourth graders who jointly and severally copied your spread sheet program and then improved it?

- How much can you afford to invest in protection?
- How aggressive can you afford to be in pursuing infringers?
- How aggressive are you willing to be? (Would you really sue the class of fourth graders who jointly and severally copied your spread sheet program and then improved it?)

One final factor to consider: you may be the defendant. Someone in this great land of ours may think that your program is based on his/hers. You may have noticed that copyright, patent, and trademark protection belongs to the first user, not the first person to register. (In some other countries, the opposite is the case.)

Therefore, regardless of whether you intend to seek formal legal protection of your software, you should keep careful, dated, notes of how you developed it. If you can spare the memory, put REM statements in each version indicating when you wrote it; if you can spare the space, keep hard copies. If you are not particularly credible (remember, if enough money is involved, someone will doubt your credibility), have a more credible third party sign the copies. Then keep a very close eye on that third party.

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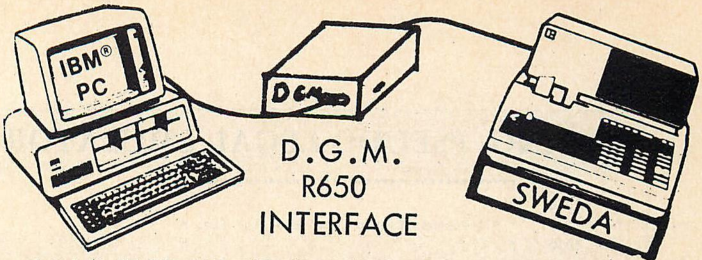

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1050 '  *                                        *
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1080 '  * person giving credit to the author     *
1090 '  * and this publication in the source     *
1100 '  * listing and accompanying text, if any  *
1110 '  *                                        *
1120 '  ******************************************
1130 CLS
1140 RANDOMIZE VAL (RIGHT$ (TIME$, 2))
1150 KEY OFF
1160 CLS
1170 DIM REPLY$(20)
1180 LIMIT = 0
1190 READ A$
1200 IF A$ = "!" THEN 1240
1210 LIMIT = LIMIT + 1
1220 REPLY$ (LIMIT) = A$
1230 GOTO 1190
1240 STALL$ = "We are researching your question now."
1250 WAFFLE$ = "  Wait a minute..."
1260 AD$ = "having reviewed your"
1270 VI$ = " program carefully, we think you should"
1280 INPUT "What is your name";NAM$
1290 FOR K = 1 TO LEN (NAM$)
1300    IF MID$ (NAM$, K, 1) = " " THEN 1320
1310 NEXT K
1320 NAM$ = LEFT$ (NAM$, K - 1)
1330 IF LEN (NAM$) <= 15 THEN 1370
1340 PRINT "I can't handle a name like ";NAM$
1350 PRINT "Try again."
1360 GOTO 1280
1370 CLS
1380 FOR RAN = 1 TO LEN (NAM$)
1390    X = INT ((10 * LIMIT * RND(1)) + .5)
1400 NEXT
1410 IF (X >= 1) AND (X <= LIMIT) THEN 1450
1420 CLS
1430 PRINT STALL$
1440 GOTO 1380
1450 A$ = REPLY$ (X)
1460 PRINT
1470 PRINT NAM$;", ";AD$;
1480 PRINT VI$
1490 PRINT A$;"."
1500 PRINT
1510 PRINT
1520 PRINT
1530 FOR B = 0 TO 2
1540    PRINT MID$ (WAFFLE$, 1 + 6 * B, 6);
1550    FOR C = 1 TO 500 : NEXT C
1560 NEXT B
1570 FOR C = 1 TO 5000 : NEXT C
1580 GOTO 1370
1590 END
1600 DATA file an application for copyright
1610 DATA apply for a patent
1620 DATA affix a trademark notice
1630 DATA bring us a copy of your employee manual
1640 DATA go into some other line of work
1650 DATA initialize the diskette to keep it from being pirated
1660 DATA expect to be sued
1670 DATA "!"
```

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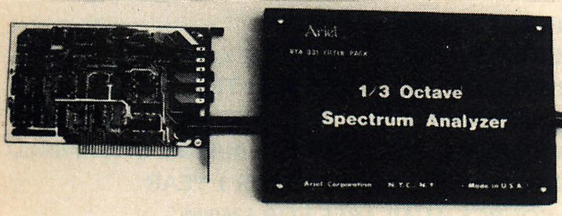

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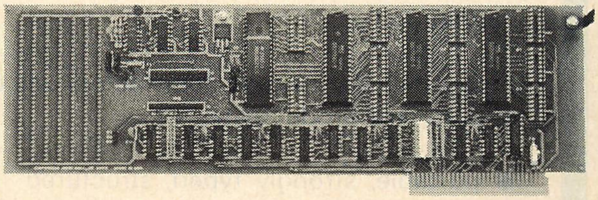
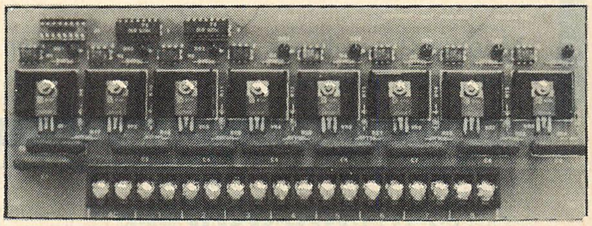


UNIVERSAL I/O. The Universal I/O board has 16 eight bit analog inputs with a voltage range of 0 to 5 volts. It also has 9 eight bit parallel I/O ports. It has interrupt circuitry, Timer clock 32768 Hz. to 512 sec., prototyping area, and LED for power. Part number 83-064A **$299.95**



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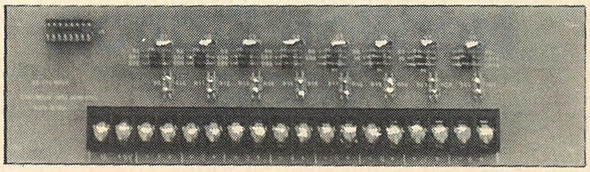

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CIRCLE NO. 214 ON READER SERVICE CARD

Nested Batch Files

A little-known DOS 2.0 feature gives batch files greater power

TECH NOTEBOOK 10

JEFF GARBERS

Batch files—lists of commands stored on disk that you can activate just by typing file names—are handy for everyone who uses DOS. An expert user can cut down his typing time or have complicated tasks performed while off getting coffee. While he's off getting coffee, novices can grab him and get him to make some batch files for them: They make life a little easier (Okay, Mr. Dithers, just put this disk in the drive and type GO).

A shortcoming of batch file processing has been that one batch file could not call another without losing control. For example, if ALPHA.BAT contains the following lines:

```
copy FILE1 FILE2
bert
copy FILE3 FILE4
```

and BETA.BAT contains

```
dir *.BAS
type LETTER1.TXT
type LETTER2.TXT
```

and you type

```
ALPHA
```

then things happen in the following order:

(1) DOS copies FILE1 to FILE2.
(2) The BETA batch file gets started up.
(3) You see a directory listing of all your .BAS files.
(4) You see the contents of the LETTER1.TXT and LETTER2.TXT files.
(5) Since BETA.BAT is now finished, you are returned to DOS command level.

There is a way to have one batch file call another without losing control, although it's far from obvious and is available only under DOS 2.00.

Notice that the last command in ALPHA.BAT—"copy FILE3 FILE4"—never took place. There appears to be no way for a batch file to say, "Look, when this other batch file is done I want to be back in control."

Fortunately, there is a way to have this happen, although it's far from obvious and is available only under DOS 2.00. Page 10-9 of your 2.00 manual describes a process called "Invoking a Secondary Command Processor," and this is the trick it takes. So, if you want to do the job properly, ALPHA.BAT should contain these lines:

```
copy FILE1 FILE2
command /C bert
copy FILE3 FILE4
```

The "command /C" on the second line tells DOS to start a new command processor. When it gets done with its job—namely doing the BETA batch file—control returns to the original command processor, which is doing the ALPHA batch file. The final COPY command takes place as desired. Using this method, batch files apparently can be nested as deeply as necessary. Each nesting level takes up slightly more than 3K of memory, which is freed up when the nested batch file is completed.

You can leave a batch file early with the EXIT command, which you'd probably only use in conjunction with the IF conditional statement. For example, let's say you didn't want to type the LETTER files if they didn't exist. You might redo BETA.BAT as follows:

```
dir *.bas
if not exist LETTER?.TXT exit
type LETTER1.TXT
type LETTER2.TXT
```

BASIC programmers will notice some parallels here—COMMAND is not unlike GOSUB, and EXIT is like RETURN. Calling a batch file the old (non-nested) way is like a GOTO.

One special note: if you intend to use the ECHO OFF command to suppress the display of each command as DOS processes it, you need to include it at the beginning of every batch file. Apparently DOS turns ECHO back on by itself every time a new batch file is started up.

If you're interested in learning how batch files can help you—and you probably should be!—take a look at pages 6-28 thru 6-49 of the DOS 2.00 manual, which discuss batch processing in great detail.

Jeff Garbers works for UserView Corporation in Atlanta, a software research and development firm specializing in human factors. He is coauthor of Crosstalk XVI.

The First Book to Read About the IBM Personal Computer
Arthur Naiman
(Houghton Mifflin Company, Boston, 1983)
103 pages, cloth, $11.95, paper, $5.95

Though its title might suggest that this is one of the new breed of contentless computer books now filling the shelves, *The First Book to Read About the IBM Personal Computer* is, in fact, a well-written, well-researched summary of the first things you might want to know about the PC. The audience for this book should be those who have a natural need for a computer (rather than just the curious). It gives a realistic picture of what small businessmen, writers, or families can expect this computer to do for them, assuming that they don't want to program it themselves.

The bulk of the book is devoted to discussions of the capabilities and prices of packages available in specific fields: money and data management, word processing, games and teaching, graphics, communications, and programming. A welcome aspect of this book is that it never forgets to discuss the cost of the hardware (modems, cables, printers) needed to support the software; nor does it forget to add in software costs when toting up typical configurations.

This book is definitely of most use *before* you buy a computer. The summary chapter gives a realistic estimate of what a useful system is finaly going to run. Typical figures are supplied for small businessmen, graphic artists, and even hobbyists (hobbyists need lots of memory). There is also a convenient table that lists systems by price range.

Just so you don't expect too much—the discussions in the chapters on available software are not deep. General capabilities and capacities are described, but the capabilities are never correlated with specific products or price ranges. Least attention is given to games, and most, to word processing. The toughest section to wade through, for both professionals and novices, is "How Computers Work," which doesn't describe how computers work but is the obligatory introduction to PC vocabulary. On the other hand "Your first time with a PC" is as true-to-life a description as I have read of a close encounter of the first kind with a new computer. It provides some genuinely useful hints for setting up the PC and reading IBM's manuals.

The book has lots of phone numbers to call if you need help, plus names and addresses of vendors. It has some good advice, and the author maintains a good attitude throughout. It even has a little French (Boca Raton) thrown in for style.

—William C. Appelbaum

PC Graphics: Charts, Graphs, Games, and Art on the IBM PC
Dick Conklin
(John Wiley and Sons, Inc., New York, 1983)
182 pages, cloth, $15.95

The complete novice interested in "doing graphics" will find this book a welcome companion to the IBM BASIC Manual. Following a brief discussion of graphics-related options on the PC and a one-page review of BASIC ("Always remember to press the Enter key after changing a program statement; doing this causes your change to be recorded in computer memory"), are chapters on line and block character graphics, medium and high resolution dot graphics, advanced BASIC features (like CIRCLE, PAINT, and DRAW), and special applications (light pens, event trapping, etc.). Each chapter concludes with three or four questions, answers, and practice problems in an obvious bid for the educational market.

The incomplete novice may be bored or insulted by some of the more elementary advice, or just puzzled by such things as the references to 16K cassette systems or the tantalizing paragraph about videodisk players that can be attached to, and controlled by, your PC. Perhaps the explanation is the author's position with IBM's Entry Systems organization as a planner for PC software. Although the book acknowledges the existence of DOS 2.0, much of it may have been written before IBM pulled out of Disco Vision. Or maybe the author knows both guys with no diskette drives on their PCs.

The sample programs and accompanying discussions are the real meat of this book, and they're quite good, though a little thinly sliced. Each program is a short, well-structured (though the phrase "structured programming" never appears) example of some idea or technique, easy to read and understand, and a good starting point for further development or experimentation; great stuff for people who have no idea where to begin, and a source of one or two new ideas for the more experienced. The range covered is broad: charts, graphs, geometric designs, several animation techniques, a simple interactive video game, even curve fitting for statistics buffs. If one doesn't interest you, turn the page; the next one will.

Realizing that the depth of explanation is purposely shallow, I was still disappointed to see an isometric drawing of a cube, modified to make the rear face smaller, passed off as 3-D graphics with "improved perspective." I guess a technically correct discussion would have taken another page or two.

If you're a programmer looking for a book on computer graphics, this isn't it. If you're new to both PCs and graphics, or are at least willing to skip the kindergarten lessons, then this is a reasonable introduction to the possibilities and techniques available with standard IBM hardware and software.

—Thomas V. Hoffmann

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Contact:
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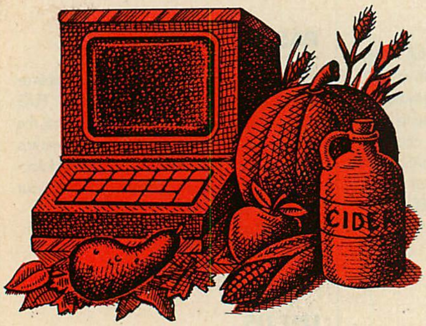
University of Texas at Austin
Austin, TX 78712



November 3–4
Workshop on Using Computers in the Employment and Education of the Handicapped
Minneapolis, MN
Sponsors:
IEEE in cooperation with ACM SIGCAPH
Contact:
Everett L. Johnson
Wichita State University, Box 44
Wichita, KS 67208, 316-689-3425

November 7–9
24th Annual Symposium on Foundations of Computer Science
Tucson, AZ
Contact:
Paul R. Young, TEO21
Evans Hall,
University of California
Berkeley, CA 94720, 415-642-1024

November 7–11
COMPSAC 83
Chicago, IL
Sponsor:
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Contact:
Compsac 83, P.O. Box 639
Silver Spring, MD 20901
301-589-8142

November 17–19
5th Annual Northeast Computer Show and Software Exposition
Boston, MA
Contact:
Northeast Expositions
822 Boylston St.
Chestnut Hill, MA 02167
617-739-2000

November 28–Dec. 2
COMDEX Fall '83
Las Vegas, NV
Sponsor:
Interface Group
Contact:
300 First Ave., Needham, MA 02194
617-449-6600

DECEMBER

December 6–8
Software Maintenance Workshop
Monterey, CA
Sponsors:
IEEE-CS and Natl. Bureau of Standards
Contact:
Norman Schneidewind, Code 54Ss
Naval Postgraduate School
Monterey, CA 93940
408-646-2719/3211

December 7–9
1983 Conference on Small and Personal Computers
San Diego, CA
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Contact:
Anne-Marie Claybrook,
The Mitre Corp.
Bedford, MA 01730, 617-271-2439

December 12–15
CHI 83, Conference on Human Factors in Computer Systems
Boston, MA
Sponsors:
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Contact:
Raoul Smith, GTE Labs
40 Sylvan Rd., Waltham, MA 02254

December 13
Computer Networking Symposium
Silver Spring, MD
Sponsor:
IEEE
Contact:
Computer Networking
P.O. Box 639
Silver Spring, MD 20901
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JANUARY

January 7–10
Consumer Electronics Show
Las Vegas, NV
Sponsor:
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Contact:
William T. Glasgow
3 Illinois Center, Suite 945,
303 E. Wacker Dr. Chicago, IL
60601, 312-861-1040

January 15–18
11th Annual ACM SIGACT-SIGPLAN Symposium on Principles of Programming Languages
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